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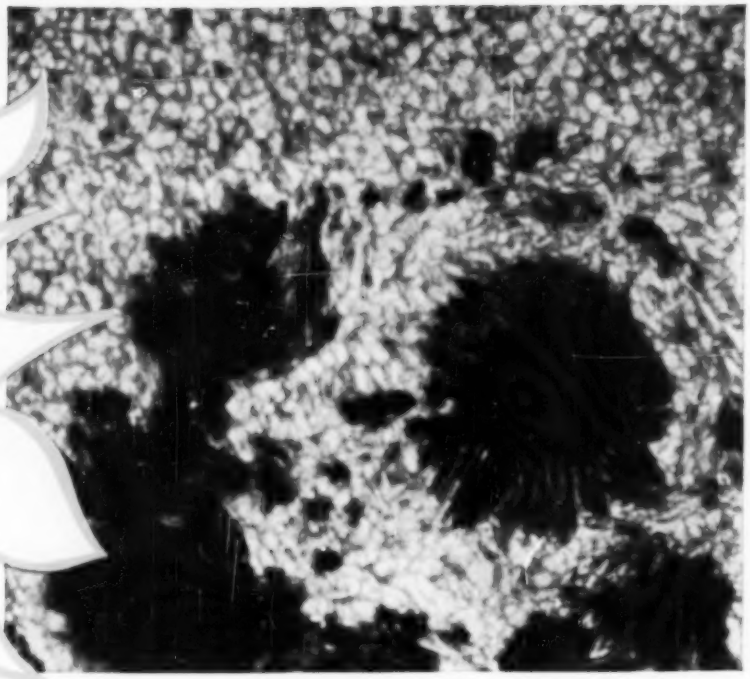

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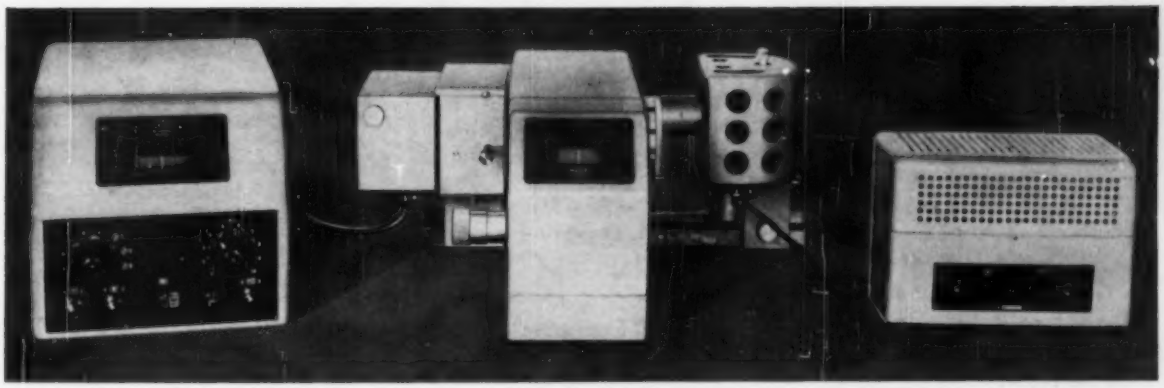

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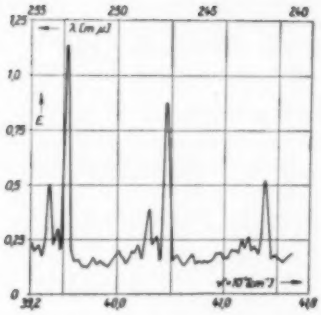

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INDUSTRIAL QUALITY CONTROL

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Establishing Performance Indexes

For Different Departments

In a Telephone Company

A. F. JACOBSON

Northwestern Bell Telephone Company, Omaha, Nebr.

IN AN operating telephone company, quality control—or perhaps quality assurance, as we look at it—is extremely important and somewhat out of the ordinary for the reason that:

(1) Service is our only product.

(2) Our operations are widely scattered. We are in small towns and big cities, farm homes and city homes, along the roads and in factories, and, of course, in your office, my office and all the business establishments and homes across the land. We also extend overseas.

(3) Our product is not one of which you can have a piece shipped into a central location for inspection and appraisal—it is tailormade and consumed on the spot—you can't send a new one to replace one that was poor in quality.

Our business is to make it possible for anyone to be able to communicate with anyone else at any time at a reasonable cost. In accomplishing this, we have to know much about the quality of the service. And, moreover, we have to know how to control the quality within economic limits—within the limits of our ability to raise capital and the users' ability to pay.

ASQC LCS Code 342:70:548

Editorial Note

This article was presented at the First Annual Conference of the Administrative Applications Division, American Society for Quality Control, Chicago, Ill., Feb. 8, 1957. It is concerned with the broad management viewpoint and administrative fundamentals in the development of performance indexes for various departments of a large telephone company. R. A. Newman considers the technical aspects of the development of such indexes in his article on page 7.

It might be asked: "Why measure the service?" "What purpose does it serve?" *We need to measure to manage.* Some years ago, a large company set forth an idea directed primarily toward detailed measurement of physical phenomena. It goes something like this . . . "One cannot manage anything that cannot be controlled, nor can one control properly that which cannot be measured." The fundamental is probably equally true of business management. This is an excellent reason for any progressive concern to be constantly seeking means of better measuring performance or product or both.

A piecepart is manufactured to specific tolerances. But a piecepart is a physical thing that can be accurately measured. If one needs to make it to ten-thousandths of an inch tolerance, that can be done. Such a piece would be considered perfect by most everyone called upon to judge it and it would probably in almost every instance perform perfectly.

Measuring service, however, is a different thing. No matter how many dollars, or how much talent, or how much supervision go into service, it still may not be perfect in all its details in the judgement of some. But, still, it must be measured by some means to know anything about costs and quality.

Fair service, good service, excellent service are relative. Telephone users have come to experience a continuous improvement in the quality of their service. The goals or standards, therefore, are moving rather than fixed targets (this keeps us flexible and alert), and our basic measurement job is to assure two things:

(1) That the service is constantly improving, and,

(2) That our costs are such that we can profitably compete with other businesses for the customer's dollar and the investor's confidence.

We think that it would be unsound to attempt to advance so rapidly down the improved service road that costs increased out of proportion to improvements made.

QUALITY controls—measurements of items bearing on both service and cost—have come to carry the board title of "indexes" in our business. In the practical meaning of "indexes" certain significant items have been selected, weighted according to importance, and combined to give a one-figure result which is a broad indication of performance.

We have service indexes on the quality of:

Long Distance Service	Local Exchange Service
Business Office Service	Maintenance Service
Installation Service	Billing Service

to name only a few, and each individual measurement plays an important part in carrying out our over-all responsibility.

Components have been selected which are important from the customer's viewpoint. They were not selected by any sudden stroke of genius. Neither were they items which were uncovered by depth interviews or public surveys, although they have been modified by such means. Instead, they are the outgrowth of a long period of technical and administrative evolution which, quite properly, still goes on.

For example, one very important measure of the service is, "Does your telephone work whenever you want to use it." This is included in what we call the maintenance index. The components making up this index are:

(a) Percentage of the telephones on which any kind of trouble is reported—appearance, loudness of the bell, breakage, can't hear—there are no exceptions.

(b) Percentage of telephones on which trouble is reported twice before we get there to repair it.

(c) Percentage of telephones on which trouble has been reported more than once within a period of one month.

(d) Percentage of telephones experiencing trouble during the day that puts them completely out of service and which we are unable to restore by midnight of the day of interruption.

Whether it is telephone service, TV service, the plumber, the electrician or service on any of the many things which go into the American way of life, various factors contribute to what one thinks about service. As you are well aware, it is one thing to know that an item has a service significance, but to be usable in quality assurance form it must also be possible to count it or measure it.

In practical application, it has occasionally been necessary to modify our viewpoint in measuring the quality of service by limiting the indexing to those subjects about which we can do something. This does not mean that we are blind to other fields and do not secure other data, but merely means that we are still in the process of evolving adequate measurements and controls for these other items. For example, our tests and inspections reveal many troubles that customers do not report, such as a receiver left off the telephone. We record, investigate and, in some cases, take action on these troubles; but we do not feel prepared at present to incorporate them in an over-all index plan.

We have had instances in the evolution of various measurements, where, in a sense, we got ahead of ourselves and unnecessarily featured items at cross-purposes with service and cost. For example, we knew that when you called us for the installation of a telephone, about half the time you would like this installation within one day. By featuring that as a component in one of our indexes we found that our own people were trying to force completion of a good deal more than 50 percent of their orders in the one-day period. In other words, we were trying to persuade people to take service earlier than they desired, and incidentally forcing up our costs. We no longer do that. We now try, insofar as possible, to offer the installation of telephones on a "when wanted" basis and our measurements are on how close we can come to this.

Roughly, our standards are established so that when the extremes of highs and lows are thrown out, a figure of 97 or 98 is assigned as the level at which service is good. This "normal" performance is based on an extremely large universe. Since we desire constant improvement, the competition within the Company and within the Bell System is to have service and costs improve above this figure. Many of the measurements are geared to the "base year type" of computation. In this we merely relate all current performance to a performance standard reached in a selected past year. Other measurements, such as work loads for operators, are based on the "standard task" reference point. For example, back around World War I days, a "standard task" which was the handling of a local call, was selected as unity and all other tasks for operators were related to this.

Obviously, progress makes these standards obsolete, so the standards are raised. On the first of January 1957 a new standard was established for the installation part of our telephone job. Its factors are based on the performance for 1955 and 1956.

In business which is everywhere rather than under one roof, it is difficult to have all measurements absolutely accurate. It is important, however, to have reasonable accuracy and this is obtained in several ways.

(1) Whenever it is possible, the components of the measurement are secured by people other than the people who are responsible for the performance being measured.

(2) Certain measurements of accuracy are made on a sampling basis periodically.

(3) Relationships between similiar towns, districts, operating areas, similar climatic conditions, etc., are revealing when set down side by side and watched month by month.

(4) In spite of our efforts, it is frequently necessary to be dependent upon an individual reporting information upon

which his own performance is judged . . . in a sense, measuring himself. Obviously in such cases audits or cross-checks are made to reveal the accuracy of reporting. For example, in our company, an installation foreman will make quality inspections on certain jobs performed by people in his own force group. These inspections are reviewed by a coordinator who can assist all foremen in looking at the job in nearly the same way.

Since most of our measurements have been involved in the process of evolution over many years they are fairly well understood, and there has been general acceptance by the people that the job should be measured. I do not mean to imply that there is complete harmony in this respect nor complete acceptance of the measurement plans, but in general the average supervisor and craftsman desire to be measured in order to obtain recognition. It is by this means that one can take pride in the results of his or her efforts. Most everyone wants to know that his efforts did accomplish something worthwhile. By measurements, the telephone company, even though in some ways a natural monopoly, maintains the keen competition essential to its never-ending vitality.

WE HAVE modified the concept and the components of quality measurements in the past. We know we will in the future. The requirments are everchanging because service concepts are everchanging. Manpower costs, new developments, new techniques, and new service requirements will necessitate new bench marks. For example, as we go further down the mechanization road, costs and techniques will obviously change. An alert force group, aware of these things, naturally questions out-of-date measurements. We should be greatly concerned if existing measurements were never questioned. A lack of questioning would imply a lack of interest. And, a real interest in measurements works toward better measurements.

The ultimate test of the quality of our service is how it satisfies the public. Consequently, as an additional quality control, we take customer attitude surveys conducted by an outside agency on a semi-annual basis. The findings give us an over-all appraisal of service quality from the customer's viewpoint as well as specific phases of our service which are pleasing or displeasing. These findings enable us to take whatever action seems appropriate to obtain greater public satisfaction. Similarly, we make attitude surveys among employees from time to time. All these act as a cross reference to guide us in the things we should meausre and the adequacy and completeness of our measurements.

It is common to use indexes to detect weak spots. It is also common to use them to find out what is happening where performances are outstanding. From both we learn a great deal. They help us to be observant and adaptable. We actually feel that we have as yet only scratched the surface in quality control. We are hoping that further knowledge on information theory, and the many devices which are being developed to aid administrative processes, will prove useful to us in securing more information even more rapidly and economically than we do now.

Measurement plans are simply a tool to inform management and help them manage. They should never control the operations. There have been cases of the measurements becoming so sacred that they overshadowed practicable management judgment in our opinion. This is the wrong concept. Indexes or controls of any kind do not take the place of on-the-job supervision and they should not be permitted to usurp management judgment and decisions.

Now, in summary, I have tried to highlight four items in connection with quality control.

First, **why measure?** We must manage—to manage we must have control—and to have control we must measure to know what is going on—in costs, performance and quality of the service.

Second, **what to measure?** Boiled down to a brief statement, measure only what is meaningful in the operations—those factors which play a big part in the costs, quality and service requirements.

Third, **how to measure?** Try to get reasonable accuracy. Keep the measurement components up to date. Keep quality controls simple so all management can understand them.

Fourth, **use the measurements as a tool**—not as a substitute for good management judgment and long practical experience.

We know we must always be striving for better means to render the best possible service at the least possible cost. Quality control or quality assurance helps us do this.

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TECHNICAL PROBLEMS IN

Establishing Performance Indexes

R. A. NEWMAN

American Telephone and Telegraph Co., New York, N. Y.

IN the telephone business we have always believed that controls based on measurement are essential ingredients in improving the quality of our service which is the product we sell. Significant service items of importance to customers have been measured since the beginning of the business. It was about 1910 that these measurements were first converted to index form.

The index, as we use it, is primarily a device to translate a number of technical measurements into a single grade or score. There are three principal advantages attached to the use of such an index as opposed to dealing directly with the technical results. First, it is a single number and therefore simple to handle. Second, the number has a universal meaning thus reducing the amount of technical knowledge required to comprehend its significance. Third, it permits conversion of a heterogeneous group of performance figures into a common denominator under which many diverse operating units can compete with each other for recognition of good results.

The indexing is achieved by means of rating tables which are designed with three main objectives in mind:

(1) Setting the top of the scale at a performance level obtainable only by very good work under favorable conditions.

(2) Keeping normal operating levels between 90 and 100. The performance levels assigned to this range should be high enough to insure good quality work but not so high as to incur unreasonable costs.

(3) Scaling points in such a manner as to reduce the possibility that poor work on one feature can be completely offset by good work on another.

Currently, indexes designed to indicate the quality of service are in use in all operating departments and in all localities where the scope of operations is extensive enough to justify the cost of measurement. The Service Index for a given month in a specified locality is a composite statement, in index form, of service performance measurements on a number of component items. For example, the Commercial Department Business Office Contact Service Index contains five component items, namely:

(1) Errors
(2) Irregularities
(3) Improper manner
(4) Slow attention
(5) Delays during contact

In computing the value of this Service Index the service performances for the five components are first measured. Each of these component measurements is then converted into an index number through the use of a Bell System curve for index rating of service performance on that component item. An illustration of a typical rating curve is shown in Fig. 1. Finally the composite Service Index value is obtained by computing a weighted average of the component index values. The weights represent the relative importance of the component items in the composite Service Index. Thus, by this procedure, Service Indexes can be computed for each locality in the Bell System where service performance measurements are made.

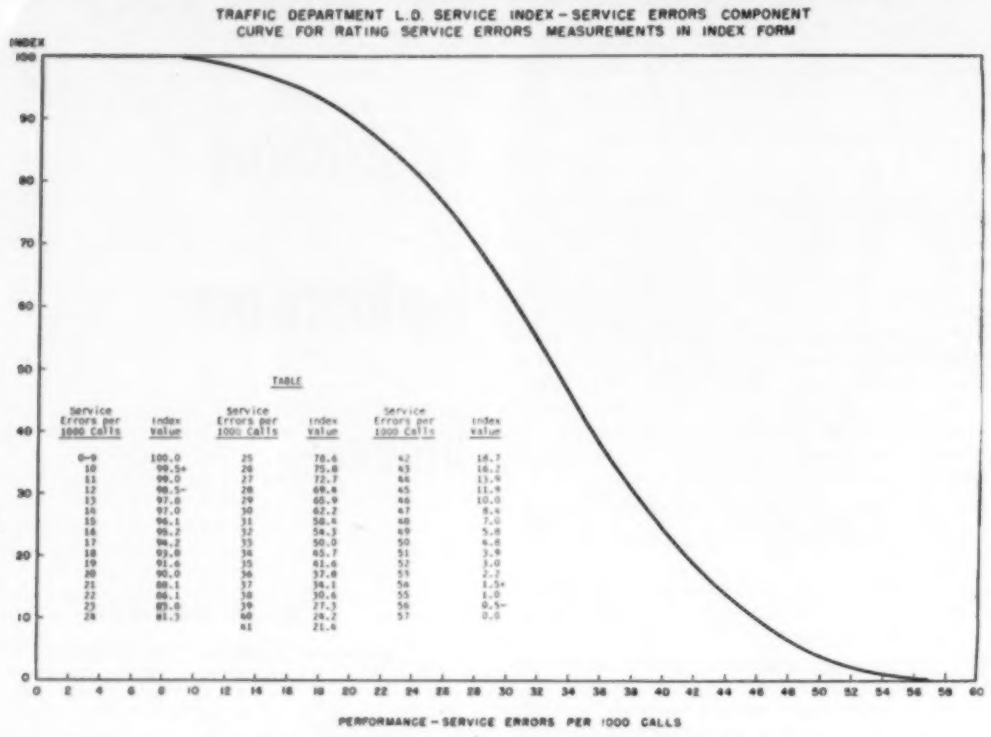
An important function of the Service Index is to provide management with a simple means of gauging comparative service performance in the various localities and operating companies. Comparisons are made between groups doing the same job in different localities as well as between groups doing different jobs. Trends are also compared over a period of time.

The provision of a uniform method of constructing index rating curves for all of the departmental service indexes, to the end that comparability between the various indexes would be achieved, is of course a major technical problem.

The rating curve shown on Fig. 1 illustrates how service performance measurements are converted to index form. By using either the curve or table the service performance measurements can be converted into index numbers. Reference to this particular curve and table indicates that performance at a level of nine errors per 1000 calls or better is given an index rating of 100. When the performance level drops, that is, when the errors per 1000 calls increase from 9 to 14 the corresponding index rating drops gradually from 100 to 97. As the errors per 1000 calls increase from 14 to 20 the index curve drops somewhat more rapidly from 97 to 90. Thereafter, as the errors per 1000 calls increase the rating curve drops more sharply until at a performance level of 46 errors per 1000 calls the rating index is ten. From 46 to 57 errors per 1000 calls the rating curve declines rather gradually from ten to zero.

ASQC LCS Code 342:70:548

Service Errors Component Curve for Rating Service Errors Measurements in Index Form


TRAFFIC DEPARTMENT L.D. SERVICE INDEX – SERVICE ERRORS COMPONENT
CURVE FOR RATING SERVICE ERRORS MEASUREMENTS IN INDEX FORM
INDEX
PERFORMANCE – SERVICE ERRORS PER 1000 CALLS

TABLE

Service Errors per 1000 Calls	Index Value	Service Errors per 1000 Calls	Index Value	Service Errors per 1000 Calls	Index Value
0-9	100.0	25	78.6	42	18.7
10	99.5+	26	75.8	43	16.2
11	99.0	27	72.7	44	13.9
12	98.5+	28	69.6	45	11.9
13	97.8	29	66.9	46	10.0
14	97.0	30	62.2	47	8.4
15	96.1	31	58.6	48	7.0
16	95.2	32	54.3	49	5.8
17	94.2	33	50.0	50	4.8
18	93.0	34	45.7	51	3.9
19	91.6	35	41.6	52	3.0
20	90.0	36	37.8	53	2.2
21	88.1	37	34.1	54	1.5+
22	86.1	38	30.6	55	1.0
23	83.8	39	27.3	56	0.5+
24	81.3	40	24.2	57	0.0
		41	21.4		

Figure 1 — Traffic Department Long Distance Service Index

In developing the curves for rating service performance in index form the objective is to achieve comparability both within a department and between departments. This objective requires first that specific meanings be attached to given index levels and second that uniform procedures be used in the construction of the index rating curves.

The following sets forth the meanings which are attached to the key index levels:

Index Value	*Meaning*
100-99	Excellent performance, obtainable only by very good work under very favorable conditions. For certain components this may be at or close to uneconomical operating levels.
98-96	Fully satisfactory and economical performance range.
95-90	Fair to mediocre performance below which service requires special attention.
Below 90	Ranging from weak spot to definitely unsatisfactory performance.

To achieve the comparability objective, a uniform procedure is needed for determining in terms of current system performance the key index points, that is, the performance levels which are to be pegged at index values of 100, 97 and 90 respectively. A uniform procedure for determining the performance levels to be associated with these key index ratings was recently established by interdepartmental agreement.

The procedure for determining the values of the three key points which we shall refer to as P_1, P_2, and P_3 is illustrated in Table I. The data used in that tabulation refer to one component of the Traffic Department's Long Distance Service Index. The same procedure can be used to determine the performance levels of the three key points on the rating curve for any other component of any index. It is described as follows:

(1) Determine the average monthly performance level for a period covering a minimum of 24 months in each locality for which the index is to be computed. In Table I the traffic performance data covered the 24 months starting with January 1951.

(2) Construct a frequency distribution of the average monthly performance levels as illustrated in Table I. In that frequency distribution, the range of performance levels extends from 7 through 22 errors per 1000 calls. The strokes opposite each of these performance levels indicate the number of Bell System localities in which the average monthly performance for the two year period was the indicated amount. For example, a performance level of seven errors per 1000 calls was attained in two localities; eight occurred in one locality, nine in four localities and so on.

The number of localities at each performance level is listed in the column headed "Frequency" on the right side of the table.

(3) Determine the value of P_1, P_2 and P_3 as follows:

(A) Determine the best performance level remaining after excluding the upper 2½ percent of the frequency distribution. The best remaining performance level is the value of P_1.

The primary reason for excluding 2½ percent of the performance measurements from each end of the distribution in determining the values of P_1 and P_3 (see below for P_3) is to determine a range within which there is a 95 percent probability that the service performances for the component under investigation may be expected to lie. Moreover this procedure results in assigning 100 index to a very small number of localities thus increasing the likelihood that 100 is really attained only under very favorable working conditions.

The total number of localities in the frequency distribution illustrated is 165. The number of localities to be excluded according to the above directions is 2½ percent of 165 or four localities. The best performance level of the remaining localities is that of fifth locality, which had a performance of nine errors per 1000 calls. Thus, the value of P_1 is established as nine.

(B) The value of P_2 is the performance level of the median locality in the frequency distribution. In the illustration, the median locality is the 83rd one and it had a performance level of 14 errors per 1000 calls. Therefore, the value of P_2 is 14.

(C) The value of P_3 is the poorest performance level remaining after excluding the lower 2½ percent of the frequency distribution. In the example, the poorest performance after excluding the bottom four localities is that of the 161st locality which is 20. Thus the value of P_3 is 20.

The final step in the construction of the Bell System curve for rating performance measurements in index form is to fit an inverted S-type curve to the three key points thus determined. In line with the comparability stated earlier it is desirable insofar as practicable that a uniform mathematical fitting procedure be employed in constructing these rating curves. A formula employing osculating (smooth function) polynomials was developed in our Chief Statisticians Division for this purpose.

Having developed uniform rating curves a weighting system is then established so that the various components can be weighted together into an overall Service Index. Each of the components is given a weight commensurate with its relative importance in the composite operation. However, so that the overall index will remain reasonably sensitive to changes in the performance of any one component it is considered desirable to limit the number of components in one index to five and to assign at least 10 percent weight to the least important one.

Another technical problem is the establishment of uniform sampling procedures for use in determining the various performance levels. It is generally stipulated that the sample used to determine the performance results should be of such size that a unit which is actually performing at a 97 level should have no more than five chances in 100 of dropping below the 90 level due to sampling causes.

It may be of interest to know that until quality control practices were introduced as a means of evaluating the significance of changes in performance levels, it was not possible to sell the bulk of our supervisory people on the desirability of using a standard sample size for indexing purposes. In introducing quality control procedures, we show our supervisors how large samples reduce the range of fluctuation in the results, and conversely, how small samples increase its range. It soon becomes apparent to them that at any given level of performance above 90 a large sample will minimize the chances of dropping below 90 and will consequently prevent the item from coming to the attention of higher levels of management as a weakspot. It is then easier to get acceptability of the idea that only with standard sample sizes will it be possible for each group to compete fairly with every other group for a high index score.

A technical problem in interpretation of results occurs when the indexes of a great number of units are combined. There is a tendency when this is done for results to average out and conceal weak spots. To overcome this tendency of the regular index to conceal weak spots a new type of index was devised for the purpose of combin-

TABLE I—Traffic Department LD Service Index, Service Errors Component

Av. Monthly Performance Level 1951-52 (Service Errors Per 1000 Calls)	Number of Localities	Freq.	Cum. Freq.	Rating Index	Locality Performance Level	Position In Cum. Freq. Col.	Corresponding Performance Level
7	xx	2	2				
8	x	1	3				
9	xxxx	4	4- 7	100	Best Performance level after excluding upper 2½ percent of distribution	4*	$P_1 = 9$
10	xxxxx xxxx	9	8- 16				
11	xxxxx x	6	17- 22				
12	xxxxx xxxxx xxxxx xxx	18	23- 40				
13	xxxxx xxxxx xxxxx xxxxx xxxxx xxxxx	29	41- 69				
14	xxxxx xxxxx xxxxx xxxxx xxxxx	25	70- 94	97	Median performance level	83**	$P_2 = 14$
15	xxxxx xxxxx xxxxx xxxxx xxxxx	25	95-119				
16	xxxxx xxxxx xxxxx xxx	18	120-137				
17	xxxxx xxxxx	10	138-147				
18	xxxxx x	6	148-153		Poorest performance level after excluding lower 2½ percent of distribution	161*	$P_3 = 20$
19	xxxxx x	6	154-159				
20	xx	2	160-161	90			
21	xxx	3	162-164				
22	x	1	165				

*0.025(165) = 4.0 **0.50(165) = 82.5

ing large groups of units such as divisions and areas. It is now in use in one department. This index is called a uniformity index or more generally a weak spot index.

The uniformity index is computed primarily for higher management use and is designed to give a quick picture of how uniform the service really is and at the same time to make it easy to identify the weak spots which deserve special attention. It is simply the percentage of total measured items which are above the 90 level. For illustration, let us say that a division includes 20 units all of which are measured on five items, making a total of 100 measured items. If 95 of the 100 items are at or above the 90 level the uniformity index is 95. If top management wants to know the situation at the weak spots it has only to ask for identification of the items below 90. Needless to say, when used by top management this always serves as a good tool for insuring that weak spots remain few in number and that when they show up they are quickly corrected.

In conclusion, I would like to mention one more technical problem, namely that of securing more intelligent use and hence better acceptance of indexes by all levels of the organization. This of course requires training in all aspects of the indexes. How they were developed, what they mean, what they are intended to accomplish, and how they are to be interpreted. In one department, in order to further a better appreciation of the effect on results of sampling error and to obtain better acceptance and more intelligent use of indexes, practical demonstrations of sampling have been given to all levels of supervision. The demonstrations show the undesirability of judging results on a short term basis and encourage analysis of results through the use of quality control techniques.

Producing better understanding of present measurement techniques as well as finding better techniques are continuing objectives of the business.

Appendix—Procedure For Fitting Index Curves

This memorandum outlines an empirical method developed by K. W. Halbert, Supervising Statistician, American Telephone and Telegraph Co., for transforming any performance measurement P into an index I between 0 and 100. The transformation is such that if points (P, I) are plotted on coordinate paper with values of P plotted from left to right and values of I from bottom to top, then the curve

$$I = f(P)$$

has the following properties:

1. The curve will pass through the points $(P_1, 100)$, $(P_2, 97)$, and $(P_3, 90)$, where P_1, P_2, and P_3 are any chosen values of P such that $P_1 < P_2 < P_3$. For example, P_1 and P_3 can be lower and upper control limits for P, and P_2 can be the value of P midway between P_1 and P_3.
2. The curve decreases as P increases for all values of I from 100 to 0.
3. The curve is concave downward for values of $I > 50$, and concave upward for $I < 50$.
4. The curve is symmetrical about the midpoint where $I = 50$.

The index is arbitrarily assigned a value of 100 for values of $P < P_1$; and is arbitrarily assigned a value of zero for values of P beyond the smallest value of P for which $I = 0$.

In transforming P into I, it is convenient to make a preliminary transformation,

$$t_i = \frac{P_i - P_1}{P_3 - P_1}$$

$$y_i = 100 - I_i$$

so that for $i = 1, 2, 3, M$, we have the following values of I_i, t_i, and y_i corresponding to P_i:

i	P_i	I_i	t_i	y_i
1	P_1	100	0	0
2	P_2	97	t_2	3
3	P_3	90	1	10
M	P_M	50	t_M	50

where

$$t_2 = \frac{P_2 - P_1}{P_3 - P_1}$$

$$t_M = \frac{P_M - P_1}{P_3 - P_1}$$

The relationship between y and t is then assumed to be given by the polynomials

$$y_1 = a + bt + ct^d \qquad \text{for } 0 \leq t \leq 1$$

$$y_2 = A + B(t-1) + C(t-1)^2 \qquad \text{for } 1 \leq t \leq t_M$$

$$y_3 = 100 - A - B(t'-1) - C(t'-1)^2 \qquad \text{for } t_M \leq t \leq 2t_M - 1$$

$$y_4 = 100 - a - bt' - c(t')^d \qquad \text{for } 2t_M - 1 \leq t \leq 2t_M$$

where

$$t' = 2t_M - t$$

and d is a positive integer greater than 1.
The required conditions are such that

$$a = 0$$

$$b = \frac{3 - 10t_2^d}{t_2 - t_2^d}$$

$$c = 10 - b$$

$$A = 10$$

$$B = b + dc$$

$$C = \frac{40 - (t_M - 1)B}{(t_M - 1)^2}$$

Hence, the points on the curve can easily be fitted, provided we can find suitable values of d and t_M.

Mr. Halbert's investigation indicated the value of d should satisfy the following inequality:

$$0.3 < t_2 < \sqrt[d]{0.3}$$

This led him to construct the following table for finding d and t_M:

Value of t_2	d	t_M
0.30000 to 0.54772	2	2
0.54772 to 0.66943	3	2
0.66943 to 0.74008	4	2
0.74008 to 0.78600	5	1-4/5*
0.78600 to 0.81818	6	1-4/6*
0.81818 to 0.84198	7	1-4/7*
0.84198 to 0.86028	8	1-4/8*

*Use largest value of t_M not exceeding the value shown in the table, for which $t_M(P_3 - P_1)$ is an integer (or even percentage if P is a ratio).

Having determined the relationship between y and t, we can use the equations

$$P = P_1 + t(P_3 - P_1),$$

$$I = 100 - y,$$

to obtain the curve showing the relationship between I and P.

Work Sampling Techniques For Cost Estimation And Control

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Purpose

The purpose of this paper is to describe several techniques which have been found effective in a work sampling program. Putting work sampling into practice requires the successful execution of several operations such as the design of the sample, the selection of random times, the calling of these random times, the identification of activities, the classification and coding of activities, the recording of the data, and the use of an adequate method of estimation. The development and use of efficient techniques in each of these areas is required if work sampling is to give management adequate data at minimum cost.

The term "random time sampling" will be used to designate the general technique of selecting random instants and determining at each such instant some characteristic of a process or sequence. Terms such as "work sampling," "activity sampling," "behavior sampling," and "flow sampling" will be used to describe applications of the general technique.

In work sampling a random time sample is used in order to obtain an estimate of a percentage of time, an amount of time, or an amount of money. The estimate may be a percentage composition or a frequency of occurrence where neither time nor money is involved directly. The estimate may be derived from random time samples of the activity of persons, the operation of machines, the flow of objects or materials. The estimate may be used for a wide variety of managerial and technical purposes of which the following are examples: personnel utilization, machine utilization, budget planning, costing a function or project, time study allowances, causes of down time.

Work sampling requires the application of known principles of probability or random sampling. In this connection a two-fold problem

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Principle of Random Time Sampling

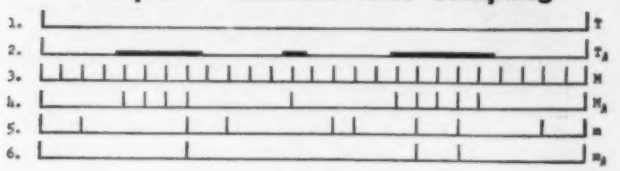

Figure 1

Design of the sample and the selection of random times are the first two steps in putting work sampling into practice. The author explains random time sampling with the aid of this diagram, which consists of six lines, each representing the same length of time T. Line 1 represents the total time under consideration T. It is a continuous variable. Line 2 shows three time segments associated with a specified activity A. The sum of these segments is T_A. Line 3 shows the continuous time line T divided into M instants, a discrete variable. Line 4 shows M_A of the M instants that hit the time segments associated with activity A. Line 5 shows a random sample of m instants drawn from the M possible instants. Line 6 shows that of these m instants, m_A match instants M_A associated with activity A.

arises: how to design a technically sound and efficient sample, and how to develop techniques which will be effective in putting the sample design into operation. In order to develop both the sample and the related techniques it is helpful to analyze the work situation to determine its nature and to formulate appropriate models for its study. Hence we begin with a description of the conditions under which random time sampling works.

Why Random Time Sampling Works

The reason random time sampling works can be explained best by a diagram which consists of six lines each representing the same length of time T. (See Fig. 1) Line 1 represents the total time under consideration T. It is a continuous variable. Line 2 shows three time segments associated with a specified activity A. The sum of these segments is T_A. Line 3 shows the continuous time line T divided into M instants, a discrete variable. Line 4 shows that M_A of the M instants hit the time segments associated with activity A. Line 5 shows a random sample of m instants drawn from the M possible instants. Line 6 shows that of these m instants, m_A match instants M_A associated with activity A.

The population value of the proportion of time P associated with activity A is as follows:

$$P = \frac{T_A}{T} \qquad (1)$$

One reason why random time sampling works is that the expected value of the proportion derived from enumerable instants is the same as the proportion derived from the continuous time variable. (See Appendix 1) In other words, in the sense of expectation

$$\frac{M_A}{M} = \frac{T_A}{T} \qquad (2)$$

The second reason why random time sampling works is that an unbiased estimate of P can be obtained by drawing at random m instants from all possible M instants, and determining how many of the m instants are associated with a specified activity A. This estimate

$$p = \frac{m_A}{m} \qquad (3)$$

is unbiased in the sense that its expected value is M_A/M. (See Appendix 2)

In the illustration given P and p have the following values. By actual measurement of T and T_A on the original diagram in 32nds of an inch $P = 40/103 = 0.388$. Based on M_A and M, $P = 10/26 = 0.385$. Based on the sample shown $p = 3/8 = 0.375$. This example is for illustrative purposes only since ordinarily estimates would not be made from such a restricted population nor from such a small sample.

The foregoing model holds even though the specified activity A, some characteristic of which we are trying to estimate, may be interspersed with other activities. This is because random sampling insures that every time segment associated with activity A is given its proper chance of being represented regardless of how many or how long these segments are. (See Appendices 1 and 2).

The Design of the Sample

The random time sampling model described above can be applied to a wide range of phenomena. Work sampling is simply one area of application where interest lies in the concept of work, its utilization and its cost. A study of the model also shows that known principles of probability sampling can be applied to the design of samples in this area.

The technical aspects of the design of a work sample are the usual ones encountered in designing a probability sample: defining the population, defining and selecting the sample unit, selecting an adequate method of estimation, determining whether or not to stratify the population and if so how, determining how to allocate the sample to the strata, and calculating sampling errors. The design is subject to two major limitations: the sampling errors which management can tolerate in the data, and the resources which management is willing to invest in a work sampling program.

TABLE I—The Activity Array

Employees	Minutes (instants or durations) 1	2	3	... j ...	M
1	A_{11}	A_{12}	A_{13}	A_{1j}	A_{1M}
2	A_{21}	A_{22}	A_{23}	A_{2j}	A_{2M}
3	A_{31}	A_{32}	A_{33}	A_{3j}	A_{3M}
•					
•					
i	A_{i1}	A_{i2}	A_{i3}	A_{ij}	A_{iM}
•					
•					
N	A_{N1}	A_{N2}	A_{N3}	A_{Nj}	A_{NM}

The design of the sample can be discussed in terms of the model outlined in Table I which consists of a two-way table with number of employees N as the stub, and the number of minutes M as the heading. This gives a total of MN employee-minutes, and since it accounts for all of the activity of the N employees it is called an activity array.

A_{ij} in the activity array is a qualitative designation which includes all types of activities. When attention is directed to a specified activity or class of activities, then a variable is introduced which has a cell value of 1 where the specified activity exists, and a cell value of 0 otherwise.

The population is defined as MN employee-minutes, with the M and the N as extensive as the problem or purpose requires. In one problem M may be a few days and N a few employees while in another problem M may be an entire year and N all of the employees.

The sampling unit, that is the unit which is selected at random, may be a single cell in the activity array. In this case it is an *employee-minute*. On the other hand the sampling unit may be a group of vertical cells in the activity array. In this case it is a *cluster-minute*. In the former case the binomial distribution can be used to estimate sampling errors, but in the latter case variance formulas appropriate to cluster sampling must be used.

For each MN cell there is not only an activity A_{ij} which is sampled by taking a random sample of m instants out of a total of M instants, but there is also a unit cost array C_{ij} showing the cost

TABLE II—The Unit Cost Array

Employees	Minutes (durations) 1	2	3 ..... j	M
1	C_{11}	C_{12}	C_{1j}	C_{1M}
2	C_{21}	C_{22}	C_{2j}	C_{2M}
3	C_{31}	C_{32}	C_{3j}	C_{3M}
•				
•				
i	C_{i1}	C_{i2}	C_{ij}	C_{iM}
•				
•				
N	C_{N1}	C_{N2}	C_{Nj}	C_{NM}

per minute of the activity under consideration. This cost may be the salary cost per minute of each of the N employees. Paralleling the activity array shown in Table I, therefore, is a unit cost array shown in Table II.

Assume that a worker receives $60.00 for a 40 hour week. Then the unit cost for this employee is $6000/40 \times 60 = 2.5$ cents per minute. This unit cost remains constant for this employee so long as his work week and weekly wage remain fixed.

A Problem Illustrating the Use of the Employee-minute

One of the problems involved in planning a budget is that of estimating the salary cost of various projects, activities, and functions on an annual basis. One way of obtaining the necessary percentages and money amounts is to apply a random time sample to all employees for an entire year.

The following example shows how we can start out with an idealized situation and then adapt our principles and procedures in order to meet a real situation. Consider the following population:

$M = 60 \times 40 \times 52 = 124{,}800$ minutes per year

$N = 350$ employees

$MN = 43{,}680{,}000$ employee-minutes per year

Assume that for each of the 43,680,000 employee-minutes a chip has been prepared indicating the presence or absence of a specified activity A. Assume further that these chips are thoroughly mixed and that a random sample of m is selected therefrom. Then the situation is analogous to coin tossing (heads or tails correspond to A or not A) and the binomial distribution is applicable with estimated mean, p, and variance, pq/m.

Assume further that we draw from a well mixed bowl containing all of these chips a random sample of 2500 chips. This is the same as drawing 2500 employee-instants where the random time used is the minute. Assume further that of these 2500 chips 250 chips showed the presence of the specified activity A, and that 2250 chips showed the presence of some other activity. Applying the characteristics of the binomial distribution we obtain the following estimates for activity A:

1. The estimate of the proportion engaged in activity A: $p = \dfrac{250}{2500} = 0.10$

2. The standard error of this proportion:

$$s_p = \sqrt{\frac{0.10 \times 0.90}{2500}} = 0.006$$

For all practical purposes, our sample is sufficiently large to allow an adequate approximation of the binomial distribution by the normal distribution. The 95 percent confidence limits for p are then given by:

$$p \pm 2\,s_p = 0.10 \pm 0.012 = 0.088 \text{ and } 0.112$$

Assume further that each of the chips shows the salary per minute of each employee. The total salary cost for a specified activity is

$$C = \sum_{i}^{M} \sum_{j}^{N} a_{ij}\, C_{ij}$$

where $a_{ij} = 1$ where the specified activity exists, and 0 otherwise. Assume m values are selected at random from MN values. Then the mean unit cost is as follows where summation is over all sample values

$$\bar{c} = \frac{1}{m}\left(\sum_{i} \sum_{j} a_{ij}\, C_{ij}\right)$$

And the total cost C for the specified activity can be estimated as follows:

$$C_{est} = MN\,\bar{c}$$

Assume a frequency distribution of salary costs derived from the sample shown as in Table III. For

TABLE III—Sample Frequency Distribution of Salary Costs

C_u (cents)	m_u	$m_u C_u$	$m_u C_u^2$
0	2250	0	0
1	0	0	0
2	50	100	200
3	150	450	1350
4	50	200	800
Sum	2500	750	2350

the specified activity, C_{ij} has five different values which for this frequency distribution are designated C_u. The mean can be calculated from this distribution where summation is over the five values of C_u:

$$\bar{c} = \frac{1}{m}\left(\sum m_u C_u\right)$$

In dollars

$$C_{est} = MN\frac{\sum m_u C_u}{m} = \frac{43{,}680{,}000 \times 7.50}{2500} = \$131{,}040$$

The sampling error of this estimate is MN times the sampling error of the mean c:

$$s_{C_{est}} = MN s_{\bar{c}} = MN\frac{s}{\sqrt{m}}$$

where s is the standard deviation of C_u obtained from the foregoing sample frequency distribution

$$s^2 = \left(2350 - \frac{750^2}{2500}\right)/2499 = 0.850340$$

Hence $s = 0.922$ and the sampling error of the estimate is as follows:

$$s_{C_{est}} = 43{,}680{,}000\,\frac{0.922}{\sqrt{2500}} = \$8{,}055$$

The relative error at the 95 percent level is about 12 percent since $16{,}109/131{,}040 = 0.12$.

The foregoing model is sound but the plan is not feasible. We cannot wait until the end of the year to draw the sample, nor is it feasible to fill out "chips" as the model requires. We can accomplish the same end however by sampling on a

daily or weekly basis: a sample plan is set up for a day or week and then repeated daily or weekly. On a daily basis N is 350 employees, M is 480 minutes, MN is 168,000 employee-minutes, and there are 260 time strata ignoring holidays. On a weekly basis N is 350 employees, M is 2400 minutes, MN is 840,000 employee-minutes and there are 52 time strata. Selecting about ten employee-minutes at random daily, or about 50 employee-minutes at random weekly would result in an annual sample of about 2500 employee-minutes.

A Problem Illustrating the Use of the Cluster-minute

In order to illustrate the use of the cluster-minute consider the following population:

$M = 2400 \times 52 = 124{,}800$ minutes per year

$N = 5$ employees

$M = 124{,}800$ cluster-minutes per year

The number of employees in the cluster engaged in the specific activity A may vary from zero to five. Assume that we draw at random ten cluster-minutes per week for a total of 520 cluster-minutes per year. This means that we select ten random times per week, and when each of these ten random times is called we find out what each of the five employees is doing, whether engaged in activity A or not. In the diagram of Table IV we show five such cluster-minutes drawn into the sample. At one of these instants none of the employees was engaged in activity A, in two instants one person was so engaged, in one instant two

TABLE IV—Array of Cluster-Minute Sample of Five

Employee	Minute (instants or durations) 1	2	3	4	5	...	j	...	M
1			—		—		A		—		A
2			—		—		—		—		—
3			—		A		A		A		A
4			—		—		—		—		A
5			—		—		—		—		—

persons were so engaged, and in one instant three of the five persons were engaged in this activity. Assume a frequency distribution of the occurrence of activity as shown in Table V

TABLE V—Sample Frequency Distribution of Activity A

Number of times A occurs in a cluster x_i	Frequency of occurrence n_i	$n_i x_i$	$n_i x_i^2$
0	110	0	0
1	330	330	330
2	75	150	300
3	5	15	45
Sum	520	495	675

The estimate of the proportion of time p devoted to activity A is $495/520 \times 5 = 0.190$. The mean number of times activity A occurred in a cluster is $\bar{x} = 495/520 = 0.952$. The standard deviation of x derived from the frequency distribution is 0.627 since

$$s^2 = \frac{1}{519}\left(675 - \frac{495^2}{520}\right) = 0.392675$$

Therefore the standard error of the mean $\bar{x}$ derived from a large number of repeated random samples of 520 clusters each, is as follows:

$$s_{\bar{x}} = \frac{0.627}{\sqrt{520}} = 0.0275$$

Assuming a normal distribution of these means, the 95 percent confidence limits for the mean are as follows:

$\bar{x} \pm 2\, s_{\bar{x}} = 0.952 \pm 0.055 = 0.897$ and 1.007

The corresponding limits for the proportion are $0.190 \pm 0.011 = 0.179$ and 0.201.

In order to estimate the salary cost of activity A derived from a random sample of cluster-minutes consider the following unit salary costs for the five employees in the foregoing example:

Employee designation: 1 2 3 4 5

Salary per minute (cents): 2 3 3 4 4

All possible sums of salaries per minute in this cluster are as follows: 0, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, and 16. (No combination of the employees will give a sum of 15 cents per minute). Assume the frequency distribution of cluster salary costs for activity A in the random sample of 520 cluster-minutes as given in Table VI.

TABLE VI—Frequency Distribution of Cluster Salary Costs

Total cents in cluster y_i	Number of clusters m_i	$m_i y_i$	$m_i y_i^2$
0	110	0	0
2	5	10	20
3	75	225	675
4	250	1000	4000
5	60	300	1500
6	10	60	360
7	5	35	245
8	5	40	320
Sum	520	1670	7120

The aggregate cost $C = M\bar{y}$ where $\bar{y} = 1670/520 = 3.2115$ cents or \$0.032115. Hence $C = 124{,}800 \times 0.032115 = \$4008$. The sampling error of this estimate is calculated from the equation $s_C = M\, s_{\bar{y}}$.

This requires first that we estimate the standard deviation of y from the foregoing frequency distribution:

$$s^2_y = \frac{1}{519}\left(7120 - \frac{1670^2}{520}\right) = 3.384838$$

$$s_{\bar{y}} = 1.840$$

Then the standard error of the mean and the standard error of the aggregate C are as follows:

$$s_{\bar{C}} = \frac{1.840}{520} = 0.08070 \text{ cents} = \$0.0008070$$

$$s_y = 124{,}800 \times 0.0008070 = \$101$$

Assuming C to be normally distributed, the confidence limits at the 95 percent level are as follows:

$C \pm 2\, s_C = 4008 \pm 202 = \$3806$ and \$4210

The relative error exceeded only five percent of the time is $202/4008 = 0.050$ or 5.0 percent.

Formulas for Estimating Sample Size

One of the basic problems in sample design is that of estimating a sample size, given certain specifications relative to sampling error and risk, and certain information about the population being sampled. We give below three formulas for estimating sample size, one in which the estimate being made is a proportion or percentage, and the others in which the estimate is an aggregate. Where both proportions and aggregates are being estimated from the sample, both types of formulas will be applied and the larger sample size used.

The formulas assume unrestricted random sampling, or sampling equivalent thereto. They give a larger sample size than is needed if an effective method of stratification is used.

If the binomial model applies to the population, then the random sample size m required to estimate a proportion is as follows:

$$m = \frac{p\,q\,t^2}{E^2} \qquad (4)$$

where

- p = proportion of employees engaged in a specified activity
- $q = 1 - p$
- t = the normal deviate which is 1.96 (or 2) for the 95 percent level
- E = absolute error to be tolerated in the proportion p

The values E and t are specified or assumed on the basis of experience; the value of p is estimated from past data, from a pilot run, or a reasonable upper or lower limit is used. For example assume $p = 0.10$, $t = 2$, and $E = 0.02$. Then the sample size m is $m = 0.10 \times 0.90 \times 4 \times 2500 = 900$

The sample size required to estimate the *total cost* C derived from cluster-minutes is as follows:

$$m = \frac{M^2 s^2 t^2}{e^2} \qquad (5)$$

where

- M = total number of minutes under consideration
- s = standard deviation of salaries per minute between clusters, for specified activity, in dollars
- t = normal deviate which is 1.96 or 2 for the 95 percent level
- e = absolute dollar error in the aggregate cost C

Also $C = M\bar{y}$ and $e = p\,C = p\,M\bar{y}$, where p is a specified relative error in C. Assume the following values:

$M = 124{,}800$ minutes (a year) $\qquad t = 2$

$s = 2.448$ cents $= \$0.02448$ $\qquad e = 268$

Then

$$M = \frac{124{,}800^2 \times 0.02448^2 \times 2^2}{268^2} = 520$$

This problem is essentially the one given above in which the sample size m is 520 cluster-minutes. A more simple form of equation 5 is the following:

$$m = \frac{c_v^2\, t^2}{p^2} \qquad (6)$$

where

c_v = the coefficient of variation of $y = \dfrac{s}{\bar{y}}$

t = normal deviate

p = the relative error in the aggregate $C = \dfrac{e}{C}$

The values p and t are specified while c_v is obtained from a knowledge of the distribution of y, the salary cost for a specified activity in a cluster-minute.

From the foregoing example $c_v = 0.5920$, $t = 2$, and $p = 0.05194$. Hence the size of the sample is

$$m = \frac{0.5920^2 \times 2^2}{0.05194^2} = 520$$

This formula is rather sensitive since the sample size m changes substantially with rather small changes in c_v or p. Rounding errors in c_v and p may cause a substantial difference in sample size derived from equation 6 compared with the sample size derived from equation 5.

Stratification

Equation 5 for sample size $m = M^2 s^2 t^2/e^2$ shows that m is a function of s^2, the variance of salary cost for activity A by clusters. The sample size m can be reduced if the population can be stratified so that s^2 is reduced. One way to accomplish this is to stratify by size of salary or wage. This stratification may already exist to some extent in the administrative section or units set up on an occupational basis. If so these sections or units can be used as strata. On the other hand some administrative sections or units may contain quite a range of salary or wage, and it may not be feasible to stratify them. If this is the case then the sample size will have to be based upon this larger variability.

In random time sampling there is an automatic stratification by time in the sense that a sample plan is based on a time unit such as a day or week, and then repeated. If differences arise between days or between weeks, they are reflected in the sample. Usually we do not change the sampling rate over time although there is no reason why we should not if we know that the population is going to change enough to warrant it.

Sample Size, Control and Stability

A sample designed primarily to give monthly or yearly cost estimates for the entire organization is usually not large enough to provide a daily or weekly control over groups of employees. In the latter case, the sample must be large enough to make satisfactory decisions on the shorter time basis. If the control is to be exerted over every employee, then the total sample will have to be even larger.

The question arises as to whether a population exists in the statistical sense in view of the fact that time and cost may not be controlled by means of some control-chart technique. Stability over time may take two forms: constancy in the proportion of time devoted to each type of activity, or a repetitive activity cycle with varying amounts of time devoted to each type of activity. This latter condition represents cyclical stability. Evidences of a population of the latter type are found in the time-period to time-period stability of the pattern of proportions of time spent on basic types of work, and in the success with which the estimates derived from one year are used to make estimates (predictions) for the next year.

Method of Selecting Random Times

The validity of random time sampling is based upon the assumption that for the time under consideration T, every time unit, such as the minute, is given a known probability of being selected. In unrestricted random sampling these probabilities are equal; in stratified random sampling they are different from stratum to stratum.

The easiest way to select random times is to use a table of random numbers. A time unit which is easy and valid to use for many problems, and which lends itself readily to the use of a table of random numbers is the minute. Two efficient methods of selecting random minutes are described below. Both use three-digit random numbers and minimize the amount of random numbers wasted.

One method is to use the first digit on the left of a three-digit random number to represent hours, and to use the two digits on the right to represent minutes from 00 through 59 within each hour, digits between 60 and 99 being ignored. With this system an appropriate coding is needed, to convert the first digit into the regular working hours. Such a one-digit code for the hours of 8:00 a.m. to 5:00 p.m. is shown in Table VII.

Note that for these working hours the minutes corresponding to 8:00 a.m. and 4:59 p.m. are subject to random selection but not the minute corresponding to 5:00 p.m. This is because we assume that employees with these working hours

TABLE VII—Code for Converting First Digit of Random Numbers to Hours

Hour	Code	Hour	Code	Hour	Code
1:00	1	4:00	4	12:00	7
2:00	2	10:00	5	8:00	8
3:00	3	11:00	6	9:00	9

are supposed to be at work at 8:00 a.m. but not at 5:00 p.m. Using this method the first five usuable numbers from a page of random numbers gave the following minutes: 151 is 1:51, 420 is 4:20, 733 is 12:33, 105 is 1:05, and 624 is 11:24.

A second method is illustrated in Table VIII which shows how any one of 720 random numbers (000-719) representing 12 hours, can be converted

TABLE VIII—Universal Table for Converting Three-Digit Random Numbers to Random Minutes

If random number falls in this interval	Then add the number in this column to the random number	To obtain a random minute in this hour
000—059	100	1:00— 1:59
060—119	140	2:00— 2:59
120—179	180	3:00— 3:59
180—239	220	4:00— 4:59
240—299	260	5:00— 5:59
300—359	300	6:00— 6:59
360—419	340	7:00— 7:59
420—479	380	8:00— 8:59
480—539	420	9:00— 9:59
540—599	460	10:00—10:59
600—659	500	11:00—11:59
660—719	540	12:00—12:59

into a random minute. This table therefore can be used to select a random minute during any time of the day or night.

Indicating Random Minutes and Recording the Data

In order to obtain valid estimates of the time and money spent on various activities using techniques described above, it is necessary to give every minute an equal or known probability of being selected. The previous section shows how to obtain an unlimited supply of random minutes. Two problems immediately arise: How to call or indicate the random minutes, and how to record the information required. Methods of indicating random minutes and methods of recording data are shown in Table IX with a broad appraisal of each.

TABLE IX—Methods of Indicating Random Minutes and Recording the Data

Methods of indicating random minutes	observer	Methods of recording the data	
		supervisor*	self-reporting
Observer	feasible**	feasible	feasible
Telephone	***	feasible	feasible
Hand-operated buzzer	***	feasible	feasible
Master clock	***	feasible	feasible

* It is feasible to use a supervisor to record the data only if the number of employees is small.
** For certain jobs where other methods are not available or feasible, an observer is required to collect the required data at designated random minutes.
*** The telephone, hand-operated buzzer, or master clock is used to eliminate observers because of their high cost and limited scope.

An observer is used to indicate random times where low cost methods are not available, or where more than an observation is required, or where the observer makes periodic tours for other reasons. The use of the telephone to call random times has many merits. It requires no new equipment or arrangements. It can be used by a central office to call random times. It is not distracting. It is flexible since it can be used to call different random times for any number of different groups of employees which are accessible to a telephone. A hand operated, or master clock operated, buzzer or bell system can be used to indicate random times as they occur. In a hand-operated system a central office can make the calls from a table of random times furnished to it. In a master clock system these random times are punched on a tape and indication is automatic. The use of these latter methods, like that of the telephone, may be limited due to limited installations.

In certain situations an observer may have to record the necessary information at indicated random times. Unless the observer is well trained in observation, identification, and classification of activity, the quality of the data obtained by this method may not be any higher than that obtained from the lower cost methods. The supervisor may be used to fill out the data sheet for each employee when a random time is called. This puts the recording in the hands of a responsible person, who is in a key position to account for absentees, employees on detail, and other personnel, and to see that the data sheets are properly filled out. It is important also to have the supervisor intimately associated with the work sample because it is the supervisor's responsibility to improve operations. A third method is to use the employees themselves to record the data. If reporting is anonymous, and the employees properly oriented and trained along the lines described in the next section, then this low-cost method will produce valid data. If each supervisor reviews the data sheets for his group after each random time is called, then serious errors in reporting can be reduced to a minimum.

The recording of data can be greatly facilitated by using a simple data sheet bound in pads, with check marks replacing writing to the maximum extent. One such data sheet calls for information relative to six items: date, time, work status, activity code, salary grade, and section identification. Date, time, and activity code require writing; the other three items require only a check mark in the appropriate box. On the average it requires only a few seconds to fill out one of these sheets.

Activity Identification, Classification and Coding

In any work sampling program the problems of identifying, classifying, and coding employee activity will arise very quickly. Careful work on these problems will be rewarding since it is easy for bias due to these causes to be as large as, or even larger, than the sampling error.

Observers should be carefully selected and given special instruction relative to the observation and interpretation of activity. This calls for specific explanations of what constitutes work activity and non-work activity, and how one interprets situations such as getting a drink, talking, walking or traveling, and "thinking." Indeed, careful explanations and instructions are necessary whether the data are recorded by observers, supervisors, or by the employees themselves.

Certain procedures which have been found helpful are the following: prepare an activity identification, classification, and coding manual to be issued to all persons involved in recording data for the work sampling program; discuss this manual with observers, supervisors, and employees in groups or individually in order to stimulate interest and to gain understanding; have supervisors give each employee the code number of every job assigned so that under a system of employee reporting the employee will have no trouble in identifying his activity when a random time is called; issue clarifications and additions to the instruction manual as new situations or problems arise and are resolved. Another method which can be used to improve the quality of observation is to have two or more observers grade the same work situations and fill out data sheets independently of one another. Then a discussion of points of difference will lead to the development of standards to be used in observing and interpreting work behavior so as to improve both the validity and reliability of such observations.

Table X is a suggested 100 activity block-coding system which provides for basic work status information, for management activities not assignable to particular jobs or projects, and for eight jobs, projects, or functions. This detail is sufficient for many management needs. The jobs, projects, or functions can be broad and still cover the basic work of the organization. If the detail specified gets too fine, the sample size required may become prohibitive, or else the area of sampling has to be so restricted that the information obtained has only limited value.

Summary

Work sampling is an application of the general technique of random time sampling. The basic equation of work sampling is derived and described in order to show that it gives unbiased estimates. An activity array and a cost array are significant aspects of the work sampling model. Employee - minutes and cluster - minutes as sampling units are distinguished and described.

Formulas are given for estimating sampling size, assuming simple or unrestricted random sampling. These formulas are satisfactory for basic planning even though, if stratification is effective, they give too large a sample size. It is also pointed out that the duration of the sample depends upon the length of the activity cycle, and that a population may exist because of cyclical stability as well as control-chart stability.

A universal table for deriving random minutes from random numbers is given, and certain aspects of the important problems of identification, classification, and coding of activity are discussed.

References

For a discussion of some managerial and personnel aspects (as well as other aspects) of an actual work sample, see:

(1) Rosander, Guterman, and McKeon, "The Use of Random Work Sampling for Cost Analysis and Control," *Journal of the American Statistical Association*, June 1958.

(2) E. J. Engquist, Jr., "Use of Cost Estimates Based on Work Sampling," *Science in Management, Proceedings, Administrative Applications Division of American Society for Quality Control*, Washington, D. C., Conference, Mar. 5-6, 1959.

(3) Mandel, Mindlin, and Farley, "Work Sampling in a Nationwide Field Organization," *Public Administration Review*, Vol. XVIII, No. 3, Summer 1958.

Appendix 1

The problem is to show that the expected value of $M_A/M = T_A/T$. Assume that some length of time T is represented by the line shown in Fig. 2

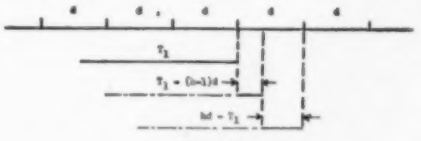

Figure 2

and that it is divided into a large number of equal intervals d. Assume that the time of duration of the first segment of activity A is T_1. Assume that T is fixed and that T_1 can take all possible positions within the interval d. In position 1, T_1 covers h points on the line. From position 2 to position 3, T_1 covers h — 1 points. In position 3, T_1 covers h points the same as in position 1, and the

TABLE X—An Illustrative 100 Activity Block Coding System

Block Code 0—9	Class Code 0—9									
	0	1	2	3	4	5	6	7	8	9
0 Work status	work plan.	leave	lunch	no job	no mat.	repair	no mach.	—	—	other
1 General Mgm't		super-visor	train.	pers.	adm.	—	—	—	—	other
2 Job A										
3 B										
4 C	(Note: To be filled out for each job or function as required)									
5 D										
6 E										
7 F										
8 G										
9 H										

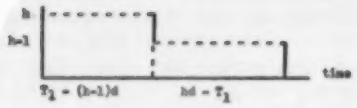

Figure 3

cycle is repeated. The number of points covered by T_1 is a function of time as indicated by Fig. 3. From this diagram

$$E(M_1) = \bar{h}$$

$$= \frac{h\,[T_1 - (h-1)d] + (h-1)(hd - T_1)}{T_1 - hd + d + hd - T_1}$$

$$= \frac{T_1}{d}$$

This can be re-written

$$E(M_1) = \frac{T_1}{d} = \frac{T_1}{T} \cdot \frac{T}{d} = \frac{T_1}{T} M$$

$$E\,\frac{M_1}{M} = \frac{T_1}{T}$$

Similarly

$$E\left(\frac{M_2}{M}\right) = \frac{T_2}{T} \ldots E\left(\frac{M_r}{M}\right) = \frac{T_r}{T}$$

where there are r segments of time associated with activity A. Therefore

$$E\left(\frac{M_1 + M_2 + \ldots + M_r}{M}\right) = \frac{T_1 + T_2 + \ldots + T_r}{T}$$

Hence

$$E\left(\frac{M_A}{M}\right) = \frac{T_A}{T}$$

Appendix 2

The problem is to show that the expected value of $m_A/m = M_A/M$. Consider the population of size M and a random sample of size m selected therefrom as shown in Table XI.

TABLE XI

Characteristic	Population	Random sample
A	M_A	m_A
Not A	$M - M_A$	$m - m_A$
Sum	M	m

The probability distribution of m_A is given by the following hypergeometric distribution where m_A takes on values 0, 1, 2, . . . , m:

$$Pr = \frac{\binom{M_A}{m_A}\binom{M - M_A}{m - m_A}}{\binom{M}{m}}$$

It can be shown that the expected value of m_A distributed in this manner is $m(M_A/M)$. (See Mood, *Introduction to the Theory of Statistics*, McGraw Hill, 1950, 98)
Hence

$$E\left(\frac{m_A}{m}\right) = \frac{M_A}{M}$$

Appendix 3

The estimate of the total cost of a specified activity is as follows where summation is over all elements in the sample whether they have activity A or not:

$$C_{est} = MN\,\frac{\Sigma m_u C_u}{m} = MN\bar{c}$$

This expression can be re-written in terms of the elements in the random sample with the specified activity A:

$$C_{est} = MN\,\frac{\Sigma m_u C_u}{m_A} \cdot \frac{m_A}{m} = MN\bar{c}_A p_A$$

where c_A is the mean unit cost of those elements with activity A while p_A is the proportion of all of the sample elements with activity A. The standard error of the estimate from the first equation $MN\sigma_{\bar{c}}$ is identical with the standard error from the second equation $MN\,c_A\,\sigma_p$ providing c_A is a constant, that is, all employees have the same unit salary cost c. The problem is to prove that $\sigma_{\bar{c}} = c\,\sigma_{pA}$ is estimated by

$$\sqrt{\frac{p_A(1 - p_A)}{m - 1}} = \sqrt{\frac{p_A - p_A^2}{m - 1}}$$

The standard error of the mean $\sigma_{\bar{c}} = \sigma/\sqrt{m}$ requires an estimate of the standard deviation σ to be derived from the sample. This is calculated

TABLE XII—Frequency Distribution of Cost C_i

Cost C_i	Frequency m_i	m_iC_i	$m_iC_i^2$
0	$m - m_A$	0	0
c	m_A	$c\,m_A$	$c^2\,m_A$
Sum	m	$c\,m_A$	$c^2\,m_A$

from the distribution of C_i given in Table XII, where C_i takes on only two values 0 and c:
From the foregoing distribution

$$s^2 = \frac{1}{m - 1}\left(c^2 m_A - \frac{c^2 m_A^2}{m}\right)$$

Therefore the standard error of the mean is as follows:

$$\sigma_{\bar{c}} = \sqrt{\frac{m(m-1)}{c^2 m_A - \dfrac{c^2 m_A^2}{m}}}$$

This reduces to

$$\sigma_{\bar{c}} = c\sqrt{\frac{1}{m - 1}\left(\frac{m_A}{m} - \frac{m_A^2}{m^2}\right)}$$

Therefore

$$\sigma_{\bar{c}} = c\sqrt{\frac{p_A - p_A^2}{m - 1}} = c\,\sigma_{pA}$$

which is the relationship required.

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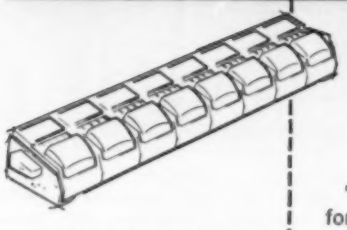

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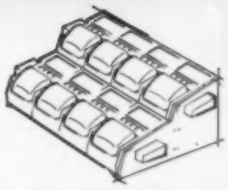

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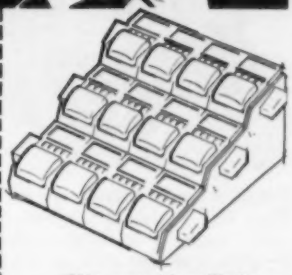

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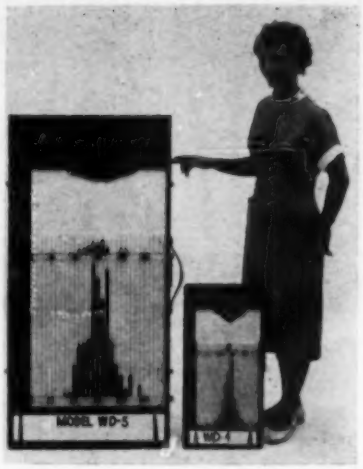
What's New?

ROY A. WYLIE, *Editor*
Ampex Corporation

P-6-2—A new dead weight gage, Type WG, designed to measure pressure, using a piston loaded with weights and operated by water, has been announced by Mansfield and Green. In this gage, the pressure acts on the piston and the thrust is balanced by weights supported on the piston. The gage is designed to operate with water to avoid the contamination and nuisance of an oil reserve, although gas, oil or any liquid not corrosive to 416 stainless steel can be used. The weights, which are supported on a tube, rotate like a pendulum. The upper end of the tube is supported by a small platform operated by the piston. The weights, by sliding over the tube and resting on a bead at the lower end, provide a low center of gravity which increases the stability and safety of operation. Weights for the minimum increment, similar to a washer, are contained by a rod and weight assembly on the upper end of the tube. A mechanical stop prevents the piston from disengaging the cylinder due to excess pressure. Because of the precision of the piston and cylinder, the Type WG gage has an average accuracy of 1/20 of 1 percent and, by selection, accuracies to 1/30 of 1 percent can be provided and certified where the gage is to be used as a primary standard.

* * *

P-5-11—The Analytical and Control Division of Consolidated Electrodynamics Corp., now offers a modification that makes its mass spectrometer type leak detectors sensitive to both argon and helium. A single switch makes it possible to alternate between the two tracer gases. This development was brought about by a shortage of helium in some areas. CEC engineers point out that helium is still the preferred tracer gas. However, where helium is unavailable or otherwise undesirable, argon can be used with the modified instrument. The argon sensitivity is at least 5×10^{-9} atm cc/sec/div and the helium sensitivity is at least 1×10^{-6} atm cc/sec/div. Argon and helium standard calibrated leaks are available for modified instruments so that quantitative leak rate measurements can be made.



P-6-9—The Lightning Calculator Company recently built a "giant" size quincunx, two feet by four feet, to fill a special order. The quincunx is a quality control training aid which permits the audience to visualize the creation of a normal distribution pattern as well as the results of variables sampling. All beads are self-contained; nothing to drop out. The quincunx, in attractive mahogany, comes complete with a zipper carrying case. The Lightning Calculator Company is inviting inquiries from quality control instructors who might be able to employ this "giant" version of the quincunx.

* * *

P-6-4—Reversible black granite surface plates that extend plate life and usefulness while effecting economies are the latest inspection equipment to be announced by the DoALL Company. They cost only one-third more than single faced plates. The new, reversible plates are available in all standard sizes from 8 inches by 12 inches to 48 inches by 144 inches. The two surfaces may have the same finish or combination of any two standard grades, AA (laboratory), A (inspection) or B (shop). All grades meet government specification GGG-P-463. Each surface is permanently identified. Removable trunnions make it easy to turn the plates. The trunnions consist of standard bolts screwed into two threaded inserts permanently imbedded in the black granite. The inserts are set flush into the center of the short sides and present no obstruction when the plate is in use. Stands have been especially designed to prevent damage to the precision surfaces of the plates. Each stand is fitted with three suspension points of protective nylon pads. The securing screws that prevent tilting under unequal loads are also nylon tipped.

Purdue University to Offer OR Short Course

A ten-day short course on Operations Research Methods will be offered at Purdue University, Lafayette, Ind.; for the first time this summer.

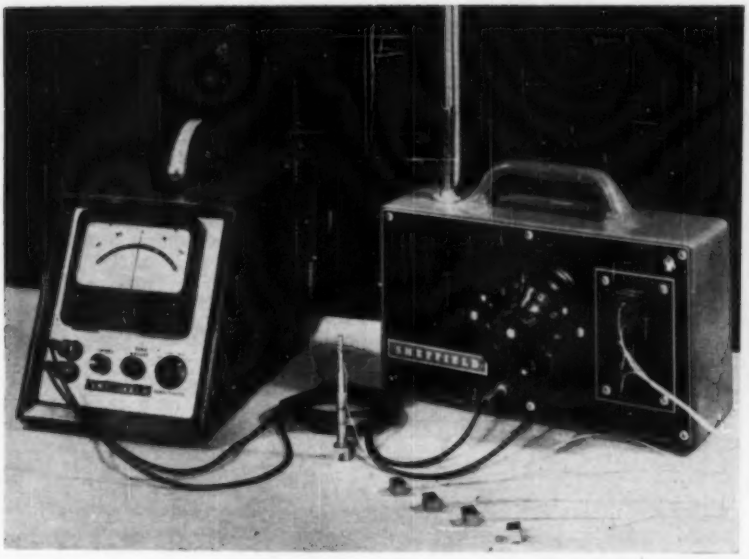
The course has been designed specifically for statisticians, quality control analysts, engineers, and other technical personnel in industrial and management positions, according to Paul H. Randolph of the department of mathematics and statistics, director of the course.

Emphasis will be placed on the methods of operations research and the application of these methods to current industrial problems.

These methods involve the construction of mathematical models representing the operation of management or an industry, and the suggestion of the best solutions to problems involved.

Among the topics to be discussed during the course are the review of probability and statistics, inventory control models, replacement models, waiting line models, linear programming, simplex method, transportation models, sequence models for production scheduling, and elements of dynamic programming.

Two outstanding leaders in this field have been selected as instructors for the short course, Albert Madansky, and Bernard Lindgren. Mr. Madansky, of the University of California, Los Angeles, did basic work in stochastic linear programming for the Rand Corporation at Santa Monica, Calif. Mr. Lindgren of the Institute of Technology, University of Minnesota, is currently a National Science Foundation scholar at Stanford University, where he is engaged in operations research.



P-6-8—The new Sheffield "Teletemp" instrument measures the temperature of precision parts, gages, instruments and machines, and the surrounding air with respect to a reference temperature. It indicates the deviation as plus or minus one-tenth, one-twentieth, or one-fortieth of a degree on the "O" center equilinear scale. Five copper constantan thermocouples with magnetic base serve as the temperature pickup units.

* * *

P-6-6—The Beckman DB Ultraviolet Spectrophotometer is a low-cost, direct reading double-beam instrument designed for rapid analyses in the 220 to 770 μ wavelength range. The new instrument will fill a wide variety of applications in agricultural, food, pharmaceutical, medical, government, and educational laboratories. The DB achieves true double-beam operation through the use of a new vibrating mirror assembly which alternately directs the monochromatic beam through the sample and reference, providing all the advantages of a double beam system. In performing a qualitative analysis, the desired wavelength is selected, sample and reference inserted, and the meter read. Separate readings for reference and sample beams are unnecessary. The DB incorporates a direct readout meter system for manual operation, reading directly in absorbance and percent transmission. It can be converted to a true percent transmission recording instrument by adding a wavelength drive accessory and a potentiometric recorder such as the Beckman Potentiometric Strip-Chart Recorder; this conversion increases the instrument's versatility by providing complete absorption spectra in a fraction of the time required by single-beam, manually operated instruments. Performance features of the DB include extremely low stray light — less than 0.5 percent over the 220 to 700 μ range. For rapid, routine applications, the programmed slit insures sufficient resolution for accurate qualitative and quantitative analysis. Resolution in the ultraviolet range is better than 1.2 μ and in the visible range better than 4.0 μ. Stability of the 100 percent line of the DB is better than ± 2.0 percent from 220 to 700 μ. Reproducibility is better than ± 1.0 percent T, while photometric repeatability is better than 0.5 percent T.

* * *

P-6-7—A new precision Hunter Force Gage with a maximum capacity of 14000 grams is now available. The new model extends to 26 the number of force indicators now being made by the firm. These force gages are available in a variety of capacities from 0-500 grams to 500 pounds. Designed for hand operation or for use in permanent test set-ups, the new L-14000 M is provided with six stainless steel attachments for the measurement of compression and tension forces. The force gage uses a compensated spring mechanism and a dial indicator with 140 divisions. The overall accuracy of the new model is ½ of one percent of full scale, equivalent to ± 70 grams. If desired, the L-14000 M is available to hold the maximum dial reading after the load has been removed. This makes it useful for measuring momentary or transient loads, and for use in awkward positions where it is difficult to read the gage dial in the test position. A control button on the instrument is used as a selection device for setting the type of operation desired, either to follow all load fluctuation or to hold the maximum reading.

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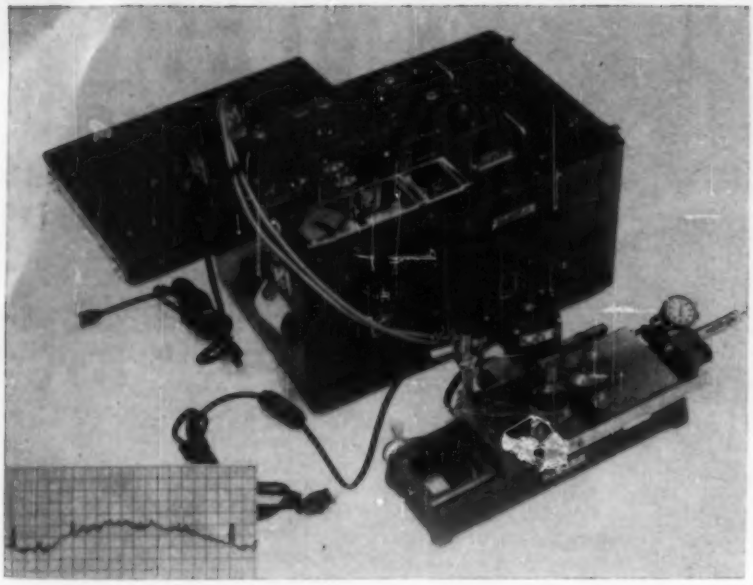

P-6-1—Now available, is an electronic gear tester using the Sanborn Electronic Recorder coupled with the Scherr 2 inch Gear Tester, the Scherr 5 inch Gear Tester or the Parkson 9 inch and 15 inch Gear Testers. The same electronic recorder can be used on any of the above gear testers simply by mounting a transducer on the gear tester. A separate transducer is required for each gear tester. The electronic recorder can be calibrated to any ratio within the limit of the recording chart. One line on the paper can be made to equal from 0.00005 inch to 0.001 inch depending upon the pitch of the gear being checked. A driving motor can be furnished to drive the gear being checked. The motor can be wired to the switch controlling the recording chart so that both gear and chart operate in unison, or it can be hooked up to an independent switch if so desired. The Electronic Recorder uses no ink but operates with an electrically heated stylus. By adjustment of a knob the stylus temperature can be adjusted to give a fine or a heavy line. Gears can be checked in pairs or against a master gear. When using master gears, a driving gear of the same pitch is required for the driving motor.

* * *

P-6-3—A recent invention has resulted in a new product allowing determination of true volume as well as the density, specific gravity or porosity of solid materials whether they be porous, granular, powdery or irregular in form. Based upon the principle that two closed systems of air at the same pressure and temperature will have identical specific volumes, this new invention allows direct digital indication of the true or absolute volume of any solid substance with only a one minute procedure. It is only necessary to insert a sample of the material to be measured into a sample container, turn one crank until forcefully stopped, turn a second crank until a gauge reads zero and then read the volume directly from a digital readout in terms of either cc or cubic inches as specified by the user. Since only air is present in the instrument, the sample is unaffected in any way. Any change in atmospheric conditions or temperature has no effect, as a comparison principle is used. The instrument is designed for field, laboratory or factory usage. It weighs sixteen pounds and encompasses a minimum of controls. It may be completely checked and calibrated in the field by non-skilled personnel. The initial instrument will have a choice of 50 cc or 100 cc sample containers. Readout will be in cubic centimeters or cubic inches as desired by the user. Accuracy is 0.1 cc with a 50 cc cup. Development is under way on additional versions having larger and smaller sample sizes. An automatic laboratory version is also being developed so that all procedures are automatic.

* * *

P-6-5—A line of extremely sensitive "sensing elements" has been developed by Crest Instruments to check corrosion of metal. The essential element of "MagnaFilm Corrosion Indicators" is a vacuum deposited film of metal 2 to 50 millionths of an inch thick. Special manufacturing techniques provide the ultrasensitivity required to detect as little as five billionths of an inch of metal loss, sensitivity so great that the progress of corrosion is detected virtually atom by atom. MagnaFilm Indicators are available both in visual and electrical versions. The Model 201 is used in small packages

Boston Reliability Training Conference

The second session of the Reliability Training Conference sponsored by the Electronics Division of ASQC and the PGRQC of IRE was held in Boston, Mass., Feb. 15-20. Twenty-seven students representing fifteen companies and military agencies attended and participated in the program which included instruction in and discussion of topics fundamental to the establishment of successful reliability engineering programs.

The Boston Training Conference was based on a similar conference presented last October in Atlantic City. The Boston Conference adhered to a much tighter schedule lasting six days rather than two weeks.

Further, extensive use was made of guest lecturers to supplement the main body of the program which was presented by Harmon S. Bayer and Thomas A. Budne, consultants retained by the ASQC-IRE National Management Committee as instructors for these conferences.

The evening sessions included talks by guest lecturers on topics, such as "Operational Reliability," "Selling Reliability to Management," and "A Case Study in Product Assurance." These lecturers also made several presentations during the regular class hours on topics that they were especially qualified to discuss.

A tabulation of written comments submitted by attendees indicate an extremely favorable acceptance of the program. Two-thirds of the replies summed the course up as being either "very good" or "extremely helpful." Many constructive comments were received and are being passed on to persons responsible for repeat sessions of this training conference in other cities.

The Boston Host Committee for this Conference consisted of Irving Bosinoff, chairman; Richard M. Jacobs; Gerald Sandler; H. Elmore Blanton; and E. F. Dertinger who served as the local representative of the National Management Committee.

of precision parts where a visual indicator is sufficient. The high contrast between the sensitized portion and the reference portion permits instant recognition of corrosive conditions. The Model 301 is essentially a good-bad electrical indicator for installation where visual indicators are not practical. The Crest Model 10 Corrosion Meter, a portable, battery-operated, hand-held instrument reads the Model 301 Indicators. The Model 501 is designed to use with Crest Corrosometers in applications where it is desirable to establish approximate rates of corrosion. MagnaFilm Corrosion Indicators have already been tested in packaging applications, to detect water in hydrocarbons and they show promise in missiles and missile systems where they can expose corrosive conditions which could harm delicate electro-mechanical components long before any actual corrosion occurs.

New Literature Available

L-6-1—Two electric tachometers for general shop and laboratory testing of rotational speeds on any type of equipment are listed in a bulletin available from The Electro-Mechano Company. Model T-101 is a portable tachometer and Model T-103 is a hand held type. Eight standard ranges are listed and special scales are also available.

* * *

L-6-2—The fundamental principles of measuring dimensions with air pressure and how these principles are used to obtain a high degree of gaging accuracy and reliability is described in a 16 MM sound, color film produced by Federal Products Corporation. Entitled "Dimensional Gaging With Air", the film shows actual tests to illustrate basic principles of air gaging while demonstrations show the practical applications and possibilities.

* * *

L-6-3—A two-page, 2 color folder describes the new Mikrom Comparator. Carbide measuring balls, backstops, lifting levers, threaded columns for fast adjustment, and fine and extra fine zero adjustments are all standard equipment. Mikrom heads are interchangeable so that one stand can be used to accommodate all.

* * *

L-6-4—A new comprehensive 40-page catalog on Riehle Universal Testing Machines is now available. It describes in detail the Riehle Electro-Balanced Indicating Unit, Riehle Screw Power Testing Machines, with capacities from 2,000 to 400,000 pounds; Riehle Hydraulic Testing Machines, with capacities from 10,000 to 400,000 pounds and a wide range of accessories and instrumentation.

* * *

L-6-5—Simplified procedures and step-by-step diagrams for measurement of insulation resistance are incorporated in a new thirty-two page manual just completed by Associated Research, Inc.

* * *

L-6-6—A forty-eight page catalog illustrates and describes 88 new Starrett tools including new satin chrome steel tapes; master vernier height gages and calipers; many new micrometer calipers, inside micrometers, micrometer depth gages and micrometer heads; satin chrome combination sets, protractors, dividers and trammels; Dial-Master indicators and dial bore gages; mechanics' tool chests; and many others.

* * *

L-6-7—Marshall Products Company has issued a specification sheet on the new 58-HD vacuum hot hardness testing furnace that includes complete engineering data on construction and performance. The 58-HD furnace was designed for hardness tests on metals at temperatures up to 3000 degrees F., in a vacuum range of 1 x 10^{-4} mm mercury.

* * *

L-6-8—The 1959 Supplements to the 1958 Book of ASTM Standards has been completed. Each part-supplement brings up-to-date the corresponding Part of the 1958 Book of Standards by including new standards and revisions adopted in 1959. The Book of ASTM Standards is published triennially with Supplements in the intervening years. The Book and Supplements contain more than 2,600 standard specifications, methods of tests, recommended practices and definitions of terms for materials.

* * *

L-6-9—Elliott Service Company is now offering a new brochure, without obligation, to business and industry executives. A publication, "Management Information for Foremen and Supervisors," provides practical techniques for problem handling in six major areas: effective communication, quality and service, waste and cost control, accident prevention, and methods improvement. Also included are samples of motivation studies, career profiles and a data book which are published every other month.

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ASQC Honors

Recent Elections to Fellow

JOSEPH E. BEEZER
Philadelphia section

Mr. Beezer was graduated from the University of Michigan in 1931, with a degree of B.S. in Electrical Engineering.

Prior to graduation from the University, he acquired considerable industrial experience in the field of radio and electronics at the General Electric Co., Schenectady, N.Y., and the Brunswick Balke Collender Co., Chicago, Ill.

He joined the inspection department of Radio Corporation of America, Camden, N.J., in 1933. In 1947, he was appointed manager, quality control, for the Camden, N.J., plant of the Engineering Products Division of RCA.

He joined the Society in 1948, and has been an active member of the Philadelphia section since that time. He has held various offices, including chairman of the Philadelphia section in 1952.

In addition to his ASQC membership, he is also a member of the Armed Forces Communications and Electronics Association and a member of the Institute of Radio Engineers.

C. W. CARTER
Western Massachusetts section

Mr. Carter was graduated from Yale University in 1942 with the degree of B.E. in Mechanical Engineering. He has done graduate work in management with the University of Connecticut.

He has held various positions with the Western Massachusetts section, presently serving as its chairman. He was also chairman of the Tenth New England Conference. Author of several articles in *Industrial Quality Control*, as well as other publications, he was co-winner of the Brumbaugh Award in 1952. He has been guest speaker at many Society meetings.

Following wartime duty as a Naval aviator, he worked for George S. Armstrong & Co.; Bigelow-Sanford Carpet Co., and Rath & Strong, Inc.

In 1959, Mr. Carter started his own practice as an Industrial Management Consultant. He is also an adjunct associate professor of management at the Hartford Graduate Center of Rensselaer Polytechnic Institute. He has served as instructor at the University of Connecticut's Advanced Statistical Quality Control Institute and guest lecturer at the Air Force Institute of Technology. He has conducted numerous in-plant training programs for Quality Control, Engineering and Research personnel.

Mr. Carter is a member of the American Society of Mechanical Engineers and a Registered Professional Engineer.

W. M. FERGUSON
Los Angeles section

After attending the University of Texas, Mr. Ferguson moved to Los Angeles, Calif., in 1938.

From 1938 to 1946, he was employed as a mechanical engineer by United Aircraft Products; in manufacturing inspection by Douglas Aircraft Co.; chief inspector by Pacific Aviation, Inc.; chief inspector for the Hi-Standard Co., and chief inspector for the Homer Seale Co.

From 1946-48, Mr. Ferguson was quality control manager for the General Tire and Rubber Co., and from 1949-50, was quality control manager for the Marquardt Aircraft Co.

The Quality Control Company, which he established in 1950, offers services in inspection systems and quality control procedures. This business today is an active distributor and manufacturer's representative specializing in inspection gages, measuring instruments, precision tools and testing equipment.

Mr. Ferguson maintains active membership in several technical and professional societies and also the Los Angeles Chamber of Commerce. A charter member of the Los Angeles ASQC section, Mr. Ferguson has served as membership and program chairman, past vice chairman, and presently chairman of the Technical Societies' Committee.

MILTON E. TERRY
Metropolitan section

Mr. Terry received his B. S. in mathematics from Acadia University in 1933, studied at Cornell University, North Carolina State College, and received his doctorate at the University of North Carolina. He has taught at Blue Ridge College, Randolph Macon Women's College, Virginia Polytechnic Institute and Rutgers • The State University of New Jersey.

In 1952 he joined the Mathematics Research Department of the Bell Telephone Laboratories, where he now heads the statistics subdepartment.

Mr. Terry is chairman of the ASQC research and development committee, and the Statistical Summer Session; a past chairman of the Princeton Conference, and the ASA Biometrics section. He is editorial consultant for Interscience — Quality Control abstracts, coeditor of the Pergammon Monograph series on Applied Statistics.

He is a member of Sigma Xi, IMS, ASA, and the Biometrics Society.

He has written a number of statistical papers and has lectured on the use of computers and statistics in Data Analysis.

HERMAN H. BOGIN
Detroit section

Mr. Bogin is a native of Connecticut and received his B. S. degree in Chemical Engineering from Yale University. Shortly after graduation, he became affiliated with Parke, Davis & Company and has been with that firm over 35 years.

For most of this period he served in the Production Division, where the high standards inherent to pharmaceutical manufacturing require rigid inspection and effective control methods.

In 1951, Mr. Bogin was transferred to a staff function, establishing the system currently used by the firm in the inspection of incoming packaging material. He has also used probability applications in the design of experiments, EVOP, and similar techniques. He has written several house manuals and various instruction guides pertaining to the Quality Control function.

He has served in various capacities in the Detroit section, including that of chairman. He was a member of the national convention committee for several years, and served as general chairman of the host committee in Detroit in 1957.

He is a member of the American Chemical Society, National Association of Business Economists, Yale Engineering Society, and Sigma Xi. Alone and with others, he has been granted more than a score of patents.

E. C. BENNETT
Los Angeles section

Mr. Bennett received his A.B. degree in physical science from Fresno State College in 1936 and completed further study in mathematical statistics, reliability, and management at USC and UCLA.

He is a founding member of ASQC, has been chairman of the Los Angeles section, and is presently national chairman of the Vendor-Vendee Relations committee.

He has held supervisory and management positions in all phases of Quality Control since 1936. Since 1940 he has been with the Northrop Corp., manufacturers of aircraft, missiles, and ground support equipment. Mr. Bennett is now chief of quality control engineering.

STANLEY S. HART
Philadelphia section

Mr. Hart has attended the University of Pennsylvania and Temple University. He is a Founding Member of ASQC and the Philadelphia section.

During the past 14 years, he has served on many committees at local, regional and national ASQC levels. He was District 5 representative in 1955-56, general chairman of the 1957 Middle Atlantic Regional Conference, Philadelphia section treasurer 1957-58, vice chairman 1959-60, and will be chairman next year.

Mr. Hart has appeared as guest speaker at ASQC section meetings as well as meetings of other professional societies and has taught a number of in-plant evening courses in QC for the Radio Corporation of America.

In his seventeen years with the Esterbrook Pen Co., Camden, N.J., he has been active in the application of statistical quality control methods as assistant chief inspector, chief inspector, and in his present position as assistant director of quality control.

JOHN B. PRINGLE
Montreal section

Mr. Pringle was graduated from McGill University in 1924 with the degree of B.Sc. (E.E.).

He is a past chairman of the Montreal section, and is at present District 4 representative, program chairman of the Electronics Division, and a member of the Committees on Constitution and By-Laws and Relations with Professional Societies.

Mr. Pringle has written several articles on applications of statistical quality control, and has been a speaker at numerous Society meetings and forums.

Since 1928, he has been with the Bell Telephone Company of Canada. His present position is staff engineer—quality analysis.

He is chairman of the Canadian Standards Association Committee on Sampling Procedures, and a member of the E-11 Committee of the American Society for Testing Materials. Mr. Pringle is also a member of the American Statistical Association, Canadian Operational Research Society, and the Corporation of Professional Engineers of Quebec.

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THOMAS E. TURNER
Indianapolis section

Mr. Turner, a native of Indiana, attended the Kirklin, Ind., high school and Monmouth College, Monmouth, Ill. He was graduated with a B.S. degree in mathematics. His education has been furthered with courses in quality control, engineering, and management at Purdue University Extension, Indiana University Extension, and Butler.

A member of ASQC since 1947, he is now a director. Mr. Turner has been very active in the Indianapolis section, having held each elective office. He has spoken extensively in the Midwest on quality control and management.

Sixteen, of his 17 years experience in active quality control work, have been in supervision and management. As chief inspector, he is presently responsible for all quality control and inspection functions at the Diamond Chain Co., Inc., Indianapolis, Ind. He is a registered professional engineer, having had extensive engineering experience. Mr. Turner started in industry with McQuay-Norris Manufacturing Co., Indianapolis Division.

He is active in community and church, an elder in a Presbyterian church, an organist and choir director, and has other hobbies including photography, guns, vacation traveling, and teaching. He conducts courses in quality control and engineering for the Purdue Indianapolis Center.

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CHESTER T. RAYMO
Tennessee section

Mr. Raymo was graduated in 1933 from the University of Tennessee with a BSME degree.

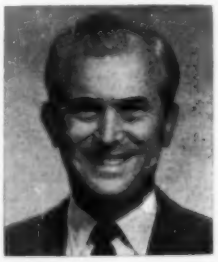
He is manager of quality control with the Steatite Division, American Lava Corp., Chattanooga, Tenn., a subsidiary of Minnesota Mining and Manufacturing Co. The Steatite Division is a manufacturer of technical ceramics.

He has delivered several papers at technical and nontechnical gatherings, and his articles have been published by *Industry and Welding, Ceramic Age,* and the West Virginia University *Bulletin.*

He has also taught at the University of Chattanooga, the University of Tennessee, the McKenzie College of Business, Chattanooga, the Kirkman Vocational High School, Chattanooga, and the Chattanooga Industrial Personnel Club.

ASQC activities include chairmanship of Tennessee and Chattanooga ASQC sections and of the examining committee and numerous programs and section conferences, and the role of ASQC district representative.

AUBREY E. WYLIE
Chapter # 1



Mr. Wylie was born in Arkansas and studied at Arkansas State College, Magnolia; Colorado State University; and the State University of New York, College of Forestry at Syracuse, where he received a Ph.D.

From 1941-46 he served with the Air Force as an aircraft maintenance officer. Various other assignments include work in industry and the U. W. Forest Service.

Mr. Wylie taught and did research in the Department of Forest Utilization at Syracuse from 1950 to 1956. At present he is on leave from Michigan State University, where he is a professor of forest products, to serve as a consultant for the Kellogg Foundation at the National University, College of Agriculture, Institute of Forestry, Medellin, Columbia.

Mr. Wylie is a member of the Forest Products Research Society, Society of American Foresters, and sigma Xi.

TAPPI Ninth Statistics Course

Application forms are now available for the 9th Pulp and Paper Statistics Course, to be held at Brevard College, Brevard, N. C., Aug. 8-19, 1960.

Requests for forms should be addressed to R. J. Hader, The Institute of Statistics, North Carolina State College, Raleigh, N. C. Attendance is limited and applications are accepted in the order received.

The fee for either the basic or the advanced section is $275, covering board and room for the two week period, textbook, and other materials. Both courses will be held concurrently.

BOOK REVIEWS

W. D. Baten, Editor

26 University Drive, East Lansing, Mich.

THE THEORY OF MATRICES, Vol. I, II, by F. R. Gantmacher (translated by K. A. Hirsch) Chelsea Publishing Co., New York, 1959, 374, 276 pages, $6.00 each volume. Reviewed by Dr. Ingram Olkin, Statistics Department, Michigan State University, East Lansing, Mich.

APPLICATIONS OF THE THEORY OF MATRICES by F. R. Gantmacher, (translated by J. L. Brenner, with the assistance of D. W. Bushaw and S. Evanusa) Interscience Publishers, Inc., New York, 1959, 317 pages, $9.00.

Although the theory of matrices is widely applied in many branches of mathematics, most books deal with the subject solely from an algebraic point of view, and omit an account of the many applications. The present book is designed to amend this situation, and indeed the author does so in a very able manner.

The original work consists of fifteen chapters. The Chelsea publication is a translation of the entire work, subdivided into two volumes covering Chapters I-X and XI-XV, respectively. The Interscience publication is a translation of Chapters XI-XV. The Chelsea books are a more formal translation, and incorporate new versions by the author of several paragraphs. The Interscience volume is more of a free translation; in order for the book to be self contained, the translators have added some footnotes and appendices. It also includes several references to more recent works. In spite of these modifications, there is virtual duplication, and it is regrettable that so much effort and work was to no avail.

Volume I deals with the more usual topics covered in a course in matrix theory. However, because the author has certain applications in mind, some material which is not customarily treated has been included.

Chapter I deals with basic operations on matrices, and includes a section on compound matrices. Except for *Determinants and Matrices*, by A. C. Aitken, this topic is either omitted or treated casually in most texts. Chapter II is concerned with the theoretical basis of Gauss's elimination method and some variants for solving linear equations. This leads to a discussion of partitioned matrices. Chapter III is entitled "Linear Operations in an N-dimensional Vector Space", and is similar to the usual treatment. The characteristic and minimal polynomials of a matrix, with numerical procedures, are considered in Chapter IV. Functions of matrices is the theme of Chapter V, and includes discussions of the Lagrange - Sylvester Interpolation Formula, series representations, and an application to a system of linear differential equations with constant coefficients. Such a system may occur when perturbations in a mechanical systems are present.

Chapters VI and VII deal with the analytic and geometric theory of elementary divisors, and some numerical methods arising from each type are given. The solution of certain matrix equations is given in Chapter VIII. Chapters IX and X cover the theory of linear operators in a unitary space and the theory of quadratic forms. Methods for reducing a quadratic form to a sum of squares are given. The discussions of Gramians and Hankel forms are of interest.

Normal forms for some special types of complex matrices, e.g. orthogonal, symmetric, skew-symmetric, are given in Chapter XI and singular pencils of matrices with an application to differential equations is given in Chapter XII.

Chapter XIII is concerned with matrices with non-negative elements, and is perhaps of greatest interest for applications in probability and statistics. Such matrices arise in the theory of Markov chains, and there are sections on stochastic matrices and limiting probabilities for homogeneous Markov chains with a finite number of states. A matrix is called totally non-negative (positive) if all of its minors of any order are non-negative (positive). A matrix is called oscillatory if it is totally non-negative, and some power of the matrix is totally positive. Such matrices exhibit certain sign oscillations and arise in a number of applications.

Chapter XIV deals with applications to linear differential equations, and is one of the principal chapters of applications. Chapter XV is concerned with the question of whether the characteristic roots have negative real parts. Such determinations are important in studying the stability of servomechanisms. An algorithm for the evaluation of the roots of a polynomial is given. It is pointed out in the Preface of the Interscience book, that codes for this method already exist.

The author states that since this book is meant to be read not only by mathematicians, but also by specialists in allied fields, he has endeavored to make this material self-contained, and that only an acquaintance with the theory of determinants is required, except for some of the later chapters, where some additional background is necessary. Readers who take this statement literally may find the text quite difficult. For persons concerned with the applications, a mastery of this material, some of which is published for the first time, may be essential; for those whose interests are peripheral, there are many sections of the book which will be most useful.

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section briefs

ALBUQUERQUE . . . W. C. Kraft, R. R. Prairie and W. J. Zimmer, all of Sandia Corp., Albuquerque, were announced as winners of the paper writing contest sponsored by the section. Mr. Kraft's paper, "The Engineering Contribution to Product Quality," was awarded a $25 prize. The $50 prize went to joint authors W. J. Zimmer and R. R. Prairie for their paper, "Some Acceptance Sampling Plans Based on the Theory of Runs." The papers were judged by a committee consisting of two members and the section officers. The papers were presented at the Mar. 14 meeting of the section.

After the banquet in May the section will hold no meetings until the fall of 1960.

ALBANY . . . On Mar. 10, J. L. Dolby, mathematical analysis section, General Engineering Laboratories, General Electric Co., presented an exceptional, interesting talk on New Developments in the closely related problem areas of (1) construction of designs for continuous variable equipment, and (2) the application of statistical methods in problems of numerical analysis.

ALLENTOWN-BETHLEHEM . . . The March meeting of our section was held at the Hotel Traylor. Another pre-meeting clinic was held, this time conducted by Miss Bonnie Small of the Allentown plant of the Western Electric Co. Miss Small's informal talk was centered about "Short Run Quality Control." The regularly scheduled meeting had for its highlight a talk on "European vs. American Standards," presented by George Williams of the Allentown plant of the General Electric Co. The meeting was well attended and both the pre-meeting clinic and the regular meeting topics were well delivered and very well received. The "Introduction to Design of Experiment" course conducted by the section in the person of Irv Yeager and taught by Ken Stephens had its last session Mar. 14. Fifteen students took advantage of the course which was held weekly at Muhlenberg College for eight weeks.

BALTIMORE . . . At the March meeting Erv Taylor, our program chairman, gave an excellent presentation on a short cut graphic method used in estimating the mean, the standard deviation, percentage out-of-specification, control limits for averages, etc. He used the FDAS, Frequency Distribution Analysis Sheet. A workshop session followed his talk in which each member of the audience worked out a problem.

Prior to the meeting Bill MacCrehan gave the sixth basic training lecture on Acceptance Sampling for Attributes. The seventh and final lecture will be given in April by our Mr. Duncan of the Johns Hopkins University. His subject will be double and multiple sampling plans.

In May we will hold our Annual Management dinner meeting. Dorian Shainin of Rath and Strong, Industrial Consultants, will be our speaker.

BATTLE CREEK-KALAMAZOO . . . A joint meeting with the Grand Rapids section was held Mar. 17, in Lansing, at the Oldsmobile Division of GMC. We participated in a plant tour of the block and piston machining plants. The tour was followed by coffee and rolls at Lundberg Screw Products, thanks to treasurer Bob Muir. The nominating committee headed by junior past chairman Bill Shideler presented a list of nominees for the coming year.

BOSTON . . . Jim Gilman of Bay State Abrasives spoke on "QC Reports to Management," at the March meeting. Judging from audience participation he illustrated how these reports could be readily adapted for use in many plants.

The evening session was preceded by an informal pre-meeting panel discussion which started at 4 p.m. The subject was "Sampling in the Chemical Industry." The panel was made up of our section chairman, D. R. Looney of Polaroid; M. S. Renner of Dewey & Almy; Warren Peckam of Monsanto Chemical, and W. E. Grady of Carter's Ink Co.

Our annual Ladies' Night was held at the MIT Faculty Club Lounge with an illustrated talk on "Keyhole Journey, A Look at the Communist World," presented by Carl de Suze of radio station WBZ.

The annual Management Series will be presented June 6-10, at the MIT Faculty Club. This series will be divided into two parts: (a) Conference June 6-8, Workshop June 9-10. Registrations will be accepted for either or both parts.

CHICAGO . . . Wednesday, May 18, the section will hold its last general meeting of the 1959-60 season at the Furniture Club of America, 666 N. Lake Shore Drive.

The 4:30 afternoon session will feature the winners of the "New Ideas Contest" who will present and discuss new techniques that can be applied to QC. The customary social hour at 5:45 will be followed by dinner at 6:30.

The evening session which begins at 7:30 promises to be a good one, hi-lighted by the initial "Joe Lisy Award."

The Award will be presented to Charles L. Matz, Commonwealth Edison Co., for his tireless efforts and never ending interest in furthering the aims and maintaining the high standards of ASQC.

The awarding of certificates to graduates of the Advanced Training Program will also take place during the evening session. Don't miss this last meeting! Keep May 18 open. Dinner reservations may be made by contacting W. Skawinski, Illinois Testing Lab., telephone WH 3-1331.

The Kankakee-Joliet ASQC section will also hold its final meeting of the season on Wednesday, May 4, in Joliet, at Tony's Restaurant, Rt. 52 (West). Kenneth E. Moore, Campbell Soup Co., will be guest speaker. Mr. Moore, a member of the Chicago section, will discuss "Applications in the Manufacture of Food Containers."

Let's turn out in force for this Kankakee-Joliet section meeting!

CINCINNATI . . . Wyatt Lewis from General Electric QC Services, New York, was the guest speaker at the Mar. 16 technical meeting. Evolution of QC from the operator control to the most recent concept, "Total Quality Control," was presented. In presenting this concept, Mr. Lewis asked the audience a number of questions which resulted in an excellent discussion that pointed out the role of "Total Quality Control."

Paul Holmstrom, the coffee talk speaker, discussed "What Makes the TV Tick?" His subject invoked a series of interesting questions regarding television.

On Mar. 23, Cincinnati section members and their guests enjoyed a plant visit through the new highly automated Ford Automatic Transmission plant located in Sharonville, Ohio.

The June 4th annual meeting and dinner dance with the Hamilton-Middletown section will be the last event of the Society's activity for the 1959-60 year. Section officers from both sections will be installed for the 1960-61 year.

COLUMBUS . . . At our section's meeting Mar. 16, at the Jeffrey Manufacturing Co., Ben Carpenter of the Union Carbide and Carbon Corp., spoke on Evolutionary Operation (EVOP). Its basic philosophy is that an operation should be run so as to generate product plus

information which can be used to improve the process and the product. An interesting question and answer session developed following the talk.

A business meeting is scheduled June 15, for officers and committeemen.

DALLAS-FORT WORTH . . . J. M. Wiesen, District 14 representative, brought an interesting and timely talk on "Professionalism in Quality Control," at the regular monthly meeting on Mar. 24. His talk was well received and created a great deal of comment.

We are looking forward to a great program for the Annual June Dinner Meeting on June 9. R. A. Glover, Temco Aircraft, is in charge of all arrangements. Recently, a survey was made on the type of program the members wanted. A large majority wanted to continue with the same type of programs as we have had in the past.

DAYTON . . . On Mar. 5, 300 persons attended the Dayton Quality Control Conference in Dayton. Leon Bass, General Electric Co., Evandale, spoke at the luncheon in place of Harry Romig, who was ill with the flu. The talk by Mr. Bass on selling top management was most interesting and informative.

Other speakers included Howard Todt of North American Aviation; Frank Squires, Consultant; J. Y. McClure, Convair; Paul Hill, Texas Instruments; Sidney Fielden, IBM; W. R. Eaton, General Electric Co.; Leo Tschechtelin, Bendix Aviation; Edward Oakley, Delco-Reamy, Division of GMC; Louis Polk, Sheffield Corp.; William Buhl of Goodrich, and C. E. McLaughlin, R. C. Littler and F. X. Brennan of Wright-Patterson AFB, Ohio.

The conference, which covered Inspection, QC, and Reliability in three series of sessions, was well received by the large group attending. The sponsoring Dayton section wishes to thank the conference committee for an excellent job, especially Bill Smith of National Cash Register, general chairman, and Major Ken Jackson, USAF Institute of Technology, program chairman.

GREATER DETROIT . . . The March Dinner Meeting was held at the General Motors Technical Center. This meeting, entitled "Application of Operations Research to Quality Control," was co-sponsored by the Greater Detroit section and the Industrial Mathematics Society. The program for the evening included a tour and demonstration of the new GMC Data Processing Center, a film presentation on "Process Development for Manufacturing Operations," the introduction of the section officers for the coming year and a presentation on "Statistical Decisions and Computers—Tools for Problem Solvers," by Frank Quackenboss, Research Assoc.

GREATER MUSKEGON . . . J. S. Dickert, superintendent of statistical quality control for Continental Motor Corp., was featured speaker for the March meeting.

Mr. Dickert spoke on Sampling Plans, discussing GMC's quality control program and sampling techniques. The meeting, attended by 51 members, was conducted by Lawrence P. Long, section chairman.

HARRISBURG . . . The June 1 meeting will be a picnic at Gladcoe Lodge, a beautiful area providing fishing, horse-shoe pitching and volley ball. The installation of the new season officers and awarding the prizes for 100 percent attendence and presentation of door prizes will be among the picnic events.

HUNTSVILLE . . . The Huntsville section took an active role in the celebration of Engineer's Week in Huntsville. Store displays illustrated phases of Quality Control. On the last evening of the week members of the local chapter participated in the dinner-dance which culminated the activities of the week. The emblem of the Society was displayed in a prominent place over the head table. The section president, Mr. Nordstrom, and his wife were seated at the guests table with representatives of other professional societies.

The plant tour May 19, will give section members an opportunity to observe some of the applications of Process Control which has produced quality in Chemstrand Corporation products.

UNIVERSITY OF IOWA . . . June 2-3, the two day meeting will be directed by Lloyd A. Knowler, department of mathematics, State University of Iowa, Iowa City, Ia. The subject is as yet unannounced; however, Mr. Knowler has always come up with the finest of meetings.

JOPLIN . . . The section held its regular monthly meeting in Joplin on Thursday evening, Mar. 24. Since representatives of several local industries are members of this organization, meetings, were held in Springfield on two recent occasions.

The Thursday night monthly meeting was held at Mickey Mantle's Holiday Inn with dinner at 7 p.m. H. O. Hehner, QC manager, Monsanto Chemical Co., St. Louis, Mo., spoke on "How You Can Make a Multi-Plant QC Program Work." Following his talk, a panel discussion concerning how local plant QC programs can differ from the over-all company program was conducted.

LEXINGTON . . . While continuing our fight with the weather, we had a fair turnout for the March dinner meeting at the Lexington Signal Depot Officer's Open Mess. The section heard a discussion on quality control in Great Britain, France and Italy by Carl Larsen, quality manager for General Tire and Rubber Co., Logansport, Ind. He stated that all the European countries have quality control societies and recounted his experience in visiting the Italian Association for Quality Control at a meeting in Milan, Italy.

Program chairman Glenn Padgett announced that plans are being firmed up for our annual dinner dance and ladies night in June.

LIMA . . . Leon Bass spoke to the section at a dinner

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meeting recounting out of his own experience anecdotes that highlighted a discussion of quality control and what management expects of it. By popular demand from both industry and individuals, the section will again offer the basic statistical quality control course that it offered last fall.

LOS ANGELES . . . On Mar. 13, the Los Angeles section was featured on a new engineering program on radio, produced by our member, Lester Gideon. Harry G. Romig was presented as the "Personality of the Week," a feature of the program. During March we had five different activities within the section which certainly points up the increased interest in quality and reliability services which the ASQC has to offer members and non-members as well. Our new Inspection Group, under the guidance of Ray Primmer, QRA, Inc., had more than 230 persons in attendance, and this was at their second meeting. Our second plant visit of the year was to the computer section of Certified Grocers in Los Angeles. The Los Angeles plant of Pabst Brewing Co., was the setting for our second social of the year. (At this type of social, any section should have a tremendous turnout!) Our regular meeting of the month brought out many wives with their member husbands to hear A. P. Stergion talk on their cooking utensils in a new way, "SQC in Glass Manufacture." Mr. Stergion, Corning Glass Works, Corning, N. Y., was bombarded with questions by inquisitive housewives. The fourth meeting of the year of the Electronics Division, had Fred Peck of Hughes Products, Semi-Conductor Division, talking on "Prediction of Early Failures in Diodes." Note to other sections: The increased activity of the section in presenting a variety of meetings to meet the members needs and wishes, has resulted in a greater interest in the society. Why not do the same?

LOUISVILLE . . . The March meeting was held on the fourteenth at Jimmy Lynn's. Preceding dinner, cocktails were enjoyed, compliments of Dick Field, Camcar Screw Co.

Vice chairman Warren Allinger opened the business meeting by welcoming back our long absent chairman, Bob Rottman, who has been on Philip Morris Quality Control business at the Venezuelan plant since last October.

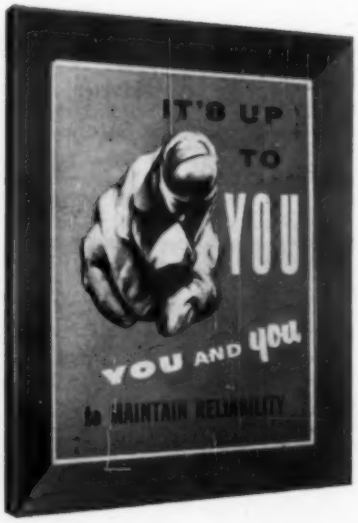
The list of nominees for various offices for 1960-61 was presented. Ballots for election of our officers will be mailed in March.

The evening's guest speaker was Donald Dunn, QC manager at IBM, Lexington, Ky. Ray Wilson, also from IBM, assisted Mr. Dunn in his informative and interesting demonstration of "Punch Cards in Statistical Quality Control." The lengthy question and answer period was indicative of the interest aroused by Mr. Dunn's presentation.

MEMPHIS . . . For our March meeting, the section was the guest of Plough Inc. Our speaker, Robert G. Brown, spoke very convincingly on sales forecasting and its effect on production and inventory control. Mr. Brown has recently written a book, *Statistical Forecasting for Inventory Control*, which was published last year by McGraw-Hill. As an important sidelight to the meeting, the section invited members of the Sales Executive Club as special guests. Refreshments were served at the conclusion of the meeting.

On May 12, the Memphis Works of International Harvester will be host to the section. Douglas Ferris will lead us on a plant tour and discuss "Moving Range Techniques as Applied to Machine Capability."

PROVIDING THE RIGHT CLIMATE



MID HUDSON . . . Frederick C. Hartwell of the Peter J. Schweitzer Division, Kimberly Clark Corp., spoke to members of this section on the Quality Control Program at Kimberly Clark. Mr. Hartwell is a quality control coordinator. His speech, "Statistical QC and Continuously Extended Materials" covered control chart techniques, analysis of variance and the use of probability paper.

MONTREAL . . . On Mar. 15, Otta A. Kral, Minnesota Mining and Manufacturing Co., St. Paul, Minn., addressed a joint meeting of the Montreal section, ASQC, and the Certified General Accountants Association. His subject was of interest to both groups and was entitled "Some Aspects of Scientific Inventory Control." He gave a graphically illustrated discussion of the underlying theories of the applied subject and related areas. In attendance were 21 members and 61 guests.

The annual dinner meeting will be held on June 8. Preparations are now in progress with the location and speaker to be announced in the near future.

NORTHEAST TENNESSEE . . . The Quality Control Clinic at the University of Tennessee, Knoxville, Tenn., was a marked success. The Management Course on the afternoon of Mar. 17, was attended by 35 persons representing quality control management throughout the South. The All Day Clinic Mar. 18, attracted 90 persons.

The clinic was sponsored by the East Tennessee section, the Tennessee section, and the University of Tennessee. Hubert Hill, East Tennessee section chairman, was general chairman of the clinic; Joe Johnston, section vice chairman, was program chairman.

A great deal of enthusiasm was shown by all who attended. The general chairman and the program chairman received many expressions of appreciation for their fine work in arranging the program. There was a strong desire to make the clinic an annual affair.

The section General Membership Meeting scheduled for Mar. 15, was rescheduled for Mar. 22. The same program and speakers were presented.

NORTHEASTERN INDIANA . . . Stephen J. Adams, Divisional Engineer for Wolverine Tube in Allen Park, Mich., spoke at the Mar. 17 meeting. His topic was "Capability Analysis." Mr. Adams accompanied his talk with a Vu-Graph presentation, which very graphically outlined his quality control program at Wolverine Tube.

Mr. Adams has had considerable experience in the quality control field and was able to answer many questions raised by the membership after his talk.

After the meeting, the members enjoyed a social hour at which coffee and donuts were served.

OMAHA-LINCOLN . . . The section met Mar. 11, at the Omaha Works, Western Electric Co. Thirty-seven members and guests were present. After dinner, J. J. Pappas, QC engineer, gave a brief sketch of QC in the Cross Bar Plant,, and D. L. Van de Water, QC supervisor in the Cable Plant, reviewed the application of QC in that plant. This was followed by a tour of both buildings.

PARKERSBURG . . . An executive meeting was held Mar. 7, at 6 p.m. in Wade's Inn.

The regular March meeting was held at the Chancellor Hotel in Parkersburg, W. Va. Members and guests had a very enjoyable evening in viewing a Johns-Manville Company film, "Modern Quality Control," with commentary by P. B. Proctor, staff manager of quality control, Johns-Manville Co.

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PENSACOLA-MOBILE . . . J. L. Field, director of quality control, hosted the members and wives of the Pensacola-Mobile section at the March meeting, held at Vanity Fair, Jackson, Ala. The meeting was of special significance for while the men were discussing the QC system employed at the plant with Mr. Field, the wives were treated to an informal showing of the latest lingerie designed and produced by Vanity Fair. The were very enthusiastic about the ladies' program, for not only were they able to get a quick look at the latest styles but it provided an opportunity for the women to get acquainted with the procedings and objectives of the Society, which we hope will result in a better understanding of our participation.

The next topic for conversation and thought will leave the region of plant product quality and enter the region of paperwork quality. The section secretary, F. J. Seguin, will present a talk entitled, "Paperwork Quality Control." Mr. Seguin is associated with the supply quality control function at Brookley AFB, and has been active in designing and implementing QC procedures in various document flow systems.

PHILADELPHIA . . . More than 60 members and guests attended and enjoyed the March meeting. Guest speaker Adolph Schaeffer gave a very interesting talk on some of the background history of the growth of steel industries in the Delaware Valley. Some general statistics of iron and steel production were mentioned, a unique one being that ten million tons a year are produced in Pennsylvania vs only two million for Texas. Early stages of iron and steel production were not much different than the old Southern plantation in the use of slave labor and the "Iron Master" who had the important position in the community as the plantation owner, according to Mr. Schaeffer.

Mr. Truax of our own Philadelphia section and Mr. Blittersdorf had the group evenly divided on the technical interests of the monthly miniature symposium. The many questions after the presentations proved of genuine interest to the group.

For those members who have not been able to attend meetings, the annual symposium will be scheduled on a Saturday in September. It is expected that a Saturday date will enable more members to attend. Further information will be forwarded to you as soon as the program is confirmed.

SACRAMENTO . . . Our March meeting was held at Parisi's Restaurant. Donald Dewing was guest speaker. Mr. Dewing is corporate manager of Reliability Assurance at Aerojet General Corp., Azusa, Calif. Mr. Dewing's topic was "Quality Control vs. Reliability." His approach was based on a wealth of engineering and statistical experience in rocket and commercial industry.

SAN DIEGO . . . The recent section meeting regarding "Human Engineering," with Mr. Rust as our speaker, was a real success. His message was most meaningful and delivered in his usual excellent fashion. Much food for thought was prevalent throughout the course of his talk.

Bob Knight, who has done a real fine job in the office of section treasurer, was recently transferred from Ryan Aircraft, San Diego, to Ryan Aircraft Facility in Torrance, Calif. We wish you the best of luck, Bob, in your new assignment.
¡Adios Amigos!

ST. LOUIS . . . The nominating committee has nominated the officers for the next year as follows: E. H. Barnett, president; M. N. Whitehead, vice president; G. S. Goodman, secretary; H. T. Bock, treasurer; W. O. Feldmeier, E. W. Corbett, and S. D. Krasner as directors.

Awards were made at the April meeting to the university students for their quality control papers. St. Louis University received three awards with Thomas Ranft winning first place with his paper entitled "Statistical Aspects of Tolerance." Washington University also received three awards.

C. T. Shewell, Humble Oil & Refining Co., Baytown, Tex., was unable to present his talk at our April meeting due to a serious heart attack. We hope Tiny recovers shortly, and look forward to hearing his talk at a later date.

SEATTLE . . . The evening of Mar. 8, section members toured the newly constructed research center laboratories of the American-Marietta Co., Seattle, Wash. This division of the company conducts basic research, product development, quality control, and technical service in the field of synthetic resin adhesives and binders and protein adhesives.

SOUTHERN CONNECTICUT . . . The Bryant Electric Co., Bridgeport, Conn., was host to the section meeting Mar. 9. John J. Riley, quality manager, the Barden Corp., made an excellent presentation on "Machine Process Capabilities." A spirited discussion followed.

Our chairman, Dave Albert, was among the guests at an Engineers' Week luncheon given by the University of Bridgeport.

On Mar. 12, 120 persons, representing 40 companies, attended an all-day "Seminar on Instrumentation and Gaging for Product Reliability," at the new Dana Hall of Science at the University of Bridgeport. The following talks were presented by experts in their respective fields: "Gage Blocks—Industry's Dimensional Standards," "Optical Gaging's Value to You," "Pitfalls of Precision Measurement," "Ultrasonic Inspection and Its Application to Thickness Gaging and Bonding Inspection," and "Hardness Testing of Sheet Metals and Cylindrical Parts." Seminar chairman Tony D'Apice and his staff are to be commended for a highly rewarding program.

SYRACUSE . . . Twenty-four students were our guests at the Student's Night meeting. We were also happy to welcome six mathematics teachers. We hope to encourage all interested teaching personnel to attend future meetings.

Two of our members, John Duffy, Cowles Chemical Co., Scaneateles Falls, and Klare L. Teegarden, Bristol Laboratories, Syracuse, each have been appointed by the Technical Societies' Council as chairmen of the advisory committee on extra-curricular educational programs at Elbridge and West Genesee Central schools, respectively. These courses will aid the schools in various ways in presenting to the students practical applications of their academic subjects in the different fields.

The four weekly panel discussions on QC held by the Auburn Industrial Management Club under the auspices of the ASQC met with such success that a Basic Course in QC is now being taught to the attendants at the discussions. Gilbert E. Schaefer, General Electric Co., Clyde, N. Y., a member of the Syracuse section, is teaching the eleven session course in Auburn.

Stephen I. Rudo

It is with deepest regret that the Metropolitan section reports that Stephen I. Rudo, 63, ASQC senior member and director of research and development of Werner Textile Consultants, N. Y., died Mar. 10, after an illness of four weeks. Mr. Rudo was born in Budapest, Hungary, and came to the United States after World War II. He studied engineering at the Technical High School in Charlottenburg, Germany, and at Budapest University, holding an M.E. degree. For 20 years he was a partner in the Grab Textile Works, Ltd., Gyoer, Hungary, which produced cotton and rayon fabrics. Before joining Werner Textile Consultants in 1949, he was director of the International Braid Corp., Fall River, Mass. Surviving is his widow, Ann.

TENNESSEE . . . The QC Clinic, jointly sponsored by the Northeast Tennessee section and the University of Tennessee, was a success! The total enrollment for the clinic was 117, and industries from both East and West Tennessee were represented, as well as firms from neighboring states.

Plans are being considered now for another clinic to be held next year. Thanks are due our members and those of the Northeast Tennessee section who helped make the clinic such a success.

We extend a hearty welcome to a new member, Jimmy Ray Miller of Yale and Towne, Lenoir City, Tenn.

UTICA . . . H. D. Voegtlen spoke on the "Abilities of Reliability," at the last meeting. These abilities include maintainability, serviceability, etc. This talk was most informative and outlined in a logical way. The costs associated with military airborne equipment after it has been delivered and is in use were among the examples employed. The amazing result was that some systems cost only a fifth of their maintenance cost during their operating life.

WASHINGTON, D. C. . . . Newly elected officers for the coming year were announced at the March meeting of the Washington ASQC section as follows: vice chairman—Chet McCall, Booz Allen Applied Research; secretary—Alfred J. McKeon, Bureau of Census, and treasurer—Elizabeth L. Umberger, Federal Aviation Agency. Present vice chairman A. C. Rosander, Internal Revenue, will be next year's chairman.

Highlight of the March meeting was a panel discussion on "Operations Research in Statistical QC and Statistical QC in Operations Research." Discussants were Paul Olmstead of Bell Telephone Laboratories and Chet McCall of Booz Allen Applied Research, Inc. Ezra Glaser, National Analysts, was chairman of the panel, and also ably substituted for Boyd Ladd of the Operations Research Office, Johns Hopkins University. Because of last minute developments, Mr. Ladd could not be present to participate as a third member of the panel as scheduled. A novel innovation for us was to have the proceedings recorded with the idea of transferring the recording from the tape recorder to a dictaphone belt and eventually publishing the transcription.

As usual, cocktails and dinner at Rich's preceded the rest of the program, for which we moved across the street from Rich's to the auditorium of the GSA Bldg.

WORCESTER . . . On Mar. 17, the Worcester section was privileged to hear a very stimulating discussion on Quality Costs, presented by Harold Freeman, General Electric Co., New York, N. Y. This discussion covered a phase of the "Total Quality Control," story which has been widely publicized by Val Feigenbaum and his associates, both in this periodical and at various clinics and conferences. Mr. Freeman showed how to break down the Quality Costs into the areas of Prevention Appraisal and Failure. He briefly explained what costs should be included in each of the three areas and then proceeded to show how the information obtained could be analyzed to obtain optimum Quality Costs. A short discussion period followed the meeting.

In the April Section Briefs item, the description of the discussion conducted during the January meeting was incorrectly reported by *Industrial Quality Control*. In retyping the copy submitted by your section reporter, R. L. Mark, your Section Briefs editor inadvertently skipped over one line of the item. Instead of, "The major part of the discussion concerned two different parametric values," the item should have read, "The major part of the discussion concerned two different techniques which could be used to evaluate two of these types of data which have non-parametric values."

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SECTION CALENDAR (MAY 25 TO JUNE 30)

SECTION	DATE	PLACE	TIME	SUBJECT	SPEAKER
Allentown-Bethlehem	June 8	Hotel Traylor, Allentown, Pa.	6:00 p.m.	Ladies' Nite	Mr. and Mrs. Ellis R. Ott, The Statistics Center, Rutgers - The State University, New Brunswick
Boston	June 6-10	MIT Faculty Club	.....	Annual Management Conference	.....
Cincinnati	June 4	Greenhills Country Club	6:30 p.m.	Annual Meeting and Dinner Dance.	.....
Dallas-Fort Worth	May 26	Arlington State College, Arlington, Tex	8:00	Overlapping Tolerances	J. A. Mazzola, IBM Corp., Endicott, N.Y.
Harrisburg	June 1	Spring Grove, Gladcoe Lodge	6:30	Annual Picnic, Officer Installation	.....
University of Iowa	June 2-3	State University of Iowa, Iowa City, Ia.	.....	To Be Announced	Program directed by Lloyd A. Knowler, State University of Iowa
Lexington	June 18	Lexington Signal Depot	8:00	Annual Dinner Dance	.....
Los Angeles	June 8	Carolina Pines	6:00	Design for Decision	Charles Bicking, Carborundum Co., Niagara Falls.
Mid Hudson	June 7	Germania Hall, Poughkeepsie, N. Y.	7:00	Final Social Meeting of the Season	.....
Montreal	June 8	To be announced	6:30	Annual Dinner Meeting	To Be announced
Omaha-Lincoln	June 10	To be announced	.....	To be announced	To be announced
Parkersburg	June 6	Wade's Inn	.....	Executive meeting	.....
San Francisco	May 24-26	Sheraton-Palace Hotel, San Francisco.	.....	14th Annual ASQC Convention and Exhibition	.....
St. Louis	June 2	West Frankfort Country Club	7:00	Management night and Presentation of Charter by the St. Louis Section	.....
Illinois Sub-Section					
Syracuse	June 28	Turn Hall	7:00	What Your Husand Does All Day Long (Ladies' Night Program)	Allin P. Deacon, Deacon and Associates, Brantford, Ontario
Utica	June 25	Picnic	.....	Members and wives invited	.....

Significant Differences

. . . Allentown-Bethlehem—The City of Allentown lost a resident when **Ken Stephens,** our genial chairman, moved to his new home in the country.

The big news here is the approaching of the occasion of our first Ladies' Night to be held in June at the Traylor. **Mr. and Mrs. Ellis R. Ott** will be present, with Mrs. Ott telling all about the trip to India with her hubby. Cocktails and dinner will be served.

. . . Baltimore—**G. A. Barnes,** chairman, training seminars, formerly of the Martin Co., Baltimore, Md., has accepted a position with the General Electric Company in Massachusetts.

. . . Boston—**Anthony Gregorio,** production engineer, CBS, Lowell, Mass., has transferred to production engineer, Sperry Rand, Norwalk, Conn.

Frederick A. Zepurneek has been shifted from laboratory technician to quality control technician.

. . . Cincinnati—The section nominating committee, composed of **Dave Birch, Bill Barker** and **Dick Race,** have nominated the following slate of candidates for the 1960-61 year: chairman—**Bob Johnson,** Kroger Co.; vice chairman—**Jim Christy,** Nutone; secretary—**Bob Ferry,** General Electric Co., and **Rudy Gruber,** General Electric Co., and treasurer—**Vernon Eklund,** Proctor & Gamble, and **Tom Ratliff,** American Standard.

. . . Cleveland—In an unprecedented move, the nominating committee unanimously nominated this year's chairman, **James T. Oesterling,** for another term as chairman. Mr. Oesterling, of Aluminum Company of America, has done such a fine job and has so many new items underway that the nominating committee thought he should head up the section for another year. Returns of the ballot show that in addition to Jim being elected chairman, **Lloyd Nelson,** General Electric Co., was unanimously nominated vice chairman. **Sam Troxel,** Ohio Bell Telephone Co., was elected treasurer and **Don Leckie,** Republic Steel Corp., was elected secretary.

. . . Dallas-Fort Worth—Officers for the 1960-61 fiscal year have been elected and announced to the members. They are: chairman—**Roger W. Anderson,** Texas Instruments; vice chairman—**Glen H. Parmeter,** Convair, Fort Worth, Tex.; treasurer—**Jack D. Brown,** Morton Foods, and secretary—**Eugenia R. Wingfield,** Convair-Fort Worth. Three directors were elected to serve for two years. They are: **Wm. E. Smith,** Chance Vought; **R. A. Glover,** Temco, and **Jack V. Button,** Bell Helicoptor.

. . . University of Iowa—Officers elected for the 1960-61 fiscal year are: chairman—**James J. Logsdon,** W. A. Sheaffer Pen Co., Fort Madison, Ia.; **Everett E. Lawson,** Philco Corp., Dexter Division, Fairfield, Ia.; secretary-treasurer—**Myron F. Wilson,** Collins Radio Co., Cedar Rapids, Ia., and three year director—**Jack E. Meyers,** International Harvester Co., Rock Island, Ill.

. . . Los Angeles—**John W. Young** has recently been elected to the new position of vice president of quality and logistics of North Amrican Aviation, Inc.

Harry G. Romig was recently selected as Personality of the Week on the radio program produced in association with the Los Angeles Technical Societies' Council.

A special educational program for inspectors and supervisions in the methods of handling inspection instruments is being conducted during Inspection Group meetings under **Ray Primmer,** QRA, Inc. Each meeting will feature a different type of product or technique.

William M. Ferguson, Quality Control Company, has been representing the Los Angeles section on the Board of Governors of the Los Angeles Technical Societies Council, which guided the Engineers' Week Activities in Los Angeles.

. . . Mid Hudson—**Richard A. Hulnick,** formerly project manager, quality control division, IBM Federal Systems Division, Kingston, N. Y., has been transferred to project manager of this Division's personnel department.

. . . Minnesota—**George Osborne,** formerly an industrial engineer with Brown and Bigelow, is now a quality control engineer for the Toni Co.

Don O'Neal has been promoted from research analyst to quality control supervisor for the Toni Co.

Ron Widell has been promoted from assistant inspection foreman to assistant quality control engineer at Honeywell's Aero Division.

. . . Montreal—The following three men have been elected and confirmed as directors of the Montreal section for a three year period: **J. Richer,** Johnson and Johnson; **S. Thomas,** Northern Electric, and **W. L. Wingfield,** Trans-Canada Air Lines.

Saddoris Award results of January 1960 indicate that this section is in second place.

. . . Northeast Tennessee—The East Tennessee section and the East Tennessee State Teachers' College are sponsoring a three-semester hour, 12 week college course in Basic Statistics. The course began Mar. 24, at the Dobyns-Bennett High School in Kingsport, Tenn.

Carl L. Wilson, section education committee chairman, is cooperating with East Tennessee State Teachers College in Johnson City in preparing a four-year evening course in analytical mathematics. The course will be for engineers and chemists and will lead to a masters degree in mathematics.

Two distinguished guests from Chrysler Missile Division, Detroit, Mich., who attended the March general membership meeting were **John Patrick,** QC manager, and **J. A. Koch,** supervisor, Eastern Region Supplier Liaison Department. Mr. Koch is a former member of the East Tennessee section.

Orville Buckaew, section member and quality manager of Magnovox-Jefferson City Plant, is attending a quality control course at the University of Tennessee in Knoxville, Tenn. The course is being presented under the direction of **Dave Chambers.**

. . . Pensacola-Mobile—Officers for the coming year are: **J. W. Comish,** chairman; **B. F. Benton,** vice chairman; **F. J. Sequin,** secretary, and **L. R. Henry,** treasurer.

. . . San Francisco—Saturday, Mar. 12, the Industrial Engineering Department of the San Jose State College held a special conference. At this conference, **Robert McKennan,** QC supervisor, Friden, Inc., spoke on "How to Use Statistical Quality Control." His program presented a complete practical survey of the details of setting up and operating a quality control system.

Walter Hurd, our District 17 representative, spoke at the first meeting of the new Vandenburg-Santa Maria section on Mar. 7.

Bruno Filice addressed the National Canners' Association at the 53rd National Convention in Miami, Fla. His subject was "Quality Control Techniques Available to the Average Canner."

Darrell Bradford, formerly of Ampex, has accepted a position with the Lockheed Missile and Space Division Reliability staff.

E. E. (Bud) Fuller, American Can Co., has been transferred from his present position as QC manager of the Oakland Plant to the quality control department of the General Manufacturing Department in New York, N.Y.

Gordon Rowe presented results of Tomato Sampling Program conducted under the guidance of the National Canners' Association Statistical Quality Control Committee Mar. 28. This meeting was sponsored by NCA, University of California, and the California Canners League.

Abe Miffler has recently been elected chairman of the National Canners' Statistical Quality Control Committee.

Robert McKennan, QC supervisor, Friden, Inc., will present a program May 13, to the California Olive Association Technical Conference in Monterey, Calif.

. . . Seattle—The Boeing Airplane Company has announced promotions for the following section members: **J. W. Griswald,** to acting director of reliability, Aero Space Division; **J. N. Paulson** to director of quality control, Aero Space Division; **H. C. Beirge** to QC manager, manufacturing operations; **J. G. Siddons** to chief, quality laboratories section; **J. A. Klinkam** to chief, quality assurance and reliability section and **B. Axman** to supervising engineering, facilities, planning and requirements, United Control Corp.

United Control Corporation recently named **D. G. Carlton** as director of QC replacing **C. W. Long,** who has been named director of technical services for the company. Both men are members of the Seattle section.

. . . Tennessee—Congratulations from the section to our chairman, **Pete Littleton.** Pete has a brand new son.

. . . Tucson—**Fred Ennerson** and **Martin A. Brumbaugh,** ASQC Fellow, (who has been a winter visitor in Tucson) addressed the graduate students in the School of Business Administration, University of Arizona, on the "Use of Statistical QC Methods in Industry," on the evening of Mar. 31. Mr. Brumbaugh mentioned the current inability of the statistician to communicate effectively with production and engineering people in his own statistical language. The statistician must therefore assume the role of interpreter in order to make his findings meaningful. Mr. Ennerson defined quality control and its specific aims.

. . . Washington, D. C.—**Catherine Hock,** formerly with the Advanced Research Projects Agency of the Technical Operations Division of the Department of Defense, has transferred to the office of Reliability and Systems Analysis of the National Aeronautics and Space Administration.

. . . Worcester—Effective Feb. 1, **Daniel J. Burda** was promoted to Division Quality Control Engineer for the American Steel and Wire Division of the U. S. Steel Corp. He replaces **Axel U. Sternlof,** fellow member and chairman of the Worcester section, who retired recently.

During most of the month of February, Mr. Sternlof and his wife were on a trip to San Antonio, Tex., where Axel presented a paper on "Industry Forging Ahead," at the all day Conference held by the San Antonio section Feb. 20.

Our Cover

Skilled craftsmen literally hold the airplane's future in their hands in the Boeing model shop at Wichita, Kans. They are a part of wind tunnel support teams at Wichita and Seattle, numbering several hundred model builders, designers, instrumentation experts and shop workers. Their specialized assignment is the transforming of new aircraft concepts into precisely detailed models. The models are used primarily for wind tunnel testing.

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ASQC Announces

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(as of March 31, 1960)

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Foster, Richard L., Dalton, Mass.
Georgis, George S., Raleigh, N. C.
Landers, John J., Pittsfield, Mass.
Noble, William O., Dalton, Mass.
Schultz, Edward F., Midland, Mich.
Smith, Chester R., Monroeville, Pa.
Spooner, Lawrence W., Pittsfield, Mass.
Thomas, Donald M., Shawnee, Kans.
Trowbridge, Joseph A., Pittsfield, Mass.
Woodin, Robert L., Poughkeepsie, N. Y.
Wright, Jacques M., Huntsville, Ala.

ADMISSIONS TO THE GRADE OF MEMBER
(as of March 31, 1960)

Abrevaya, Harry, West Roxbury, Mass.
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Aguirre, John G., Tucson, Ariz.
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ADMISSIONS TO THE GRADE OF ASSOCIATE MEMBER
(as of March 31, 1960)

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Bergerson, Omer L., Springfield, Mass.

EOQC Conference in London

The European Organization for Quality Control will sponsor a Conference Sept. 1-3, at Church House, London.

There will be simultaneous interpretation into the English and French languages of both the formal presentation of each paper and of each discussion period.

G. E. P. Box, University of Wisconsin, Madison, Wis.; Paul C. Clifford, Montclair State Teachers' College, Montclair, N. J., and Ellis R. Ott, the Statistics Center, Rutgers • The State University, New Brunswick, N. J., will be among U. S. participants in the Conference.

Thursday, Sept. 1, papers of the first main session—quality from the viewpoint of management—will be: "The Value of the Control of Product Quality," F. Nixon, U. K.; "The Establishment of a Realistic Quality Level," W. Masing, Germany, and "Achievement of the Established Quality Level," Paul C. Clifford, U. S. A.

Second main session—reducing the cost of inspection: "Developments in Qualitative Methods of Inspection," M. Leopold Micha, Belgium.

Friday, Sept. 2: "Developments in Quantitative Methods of Inspection" M. Rambach, France.

Third main session—diagnosis of trouble in manufacture: "Using Frequency Distribution for Diagnosis," Dr. Palazzi, Italy; "Short Cuts to Diagnosis," Ellis R. Ott, U. S. A., and "Economy of Planned Investigations," D. M. Cox, U. K.

Saturday, Sept. 3, fourth main session—new concepts in quality control: "Evolutionary Operation," G. E. P. Box, U. K. and U. S. A., and "Concept of Integrated Control of Product Quality," M. van Ettinger, Netherlands.

See Clinics, Conferences, and Courses, page 39, this issue.

Bubb, Clive H., Springfield, Mass.
Cielec, Stanley J., Chicago, Ill.
Cushna, Ralph A., Lake Bluff, Ill.
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THE FIVE YEAR INDEX

to

VOLUMES XI-XV

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STUDENT ENROLLMENTS
(as of January 24, 1960)

Amoroso, Michael, Flushing, N. Y.
Berson, Jack, Brooklyn, N. Y.
Magenheim, Sandra, Bronx, N. Y.
Marash, Stanley A., Brooklyn, N. Y.
Paskoff, Paul, Brooklyn, N. Y.
Scheinwald, Norman W., New York, N. Y.
Strichart, Stephen S., Bronx, N. Y.
Weiss, Neil S., Brooklyn, N. Y.

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QUALITY CONTROL: Position for person with strong statistical quality control experience. Chemistry, Chemical Engineering, or paper industry background helpful. Prefer college graduate with at least three years' experience. 30-35 years of age. Salary commensurate with experience. Send resume and salary requirement to:
Employee Relations Manager
West Virginia Pulp and Paper Company
Luke, Maryland

clinics, conferences, and courses

MAY

. . . 24-26—14th Annual Convention and Exhibition of the American Society for Quality Control, Hotel Sheraton-Palace, San Francisco, Calif.

. . . 26-28—Third ASQC Workshop-Seminar, Management of Quality Control, Sir Francis Drake Hotel San Francisco, Calif., contact the Third ASQC Workshop-Seminar, ASQC, 161 W. Wisconsin Ave., Milwaukee 3, Wis.

. . . 30-31, June 1—Mid-Pacific Conference, Honolulu.

JUNE

. . . 5-9—Summer Annual Meeting and Aviation Conference of the American Society of Mechanical Engineers, Statler Hilton Hotel, Dallas, Tex., contact L. S. Dennegar, American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.

. . . 6-10—Tenth Annual Program of Quality Control for the Graphic Industries, Rochester Institute of Technology, Rochester, N.Y., contact Harold M. Kentner, Extended Services Division, RIT, Rochester 8, N.Y.

. . . 7-17—Second Annual Short Course on the Design of Experiments, Charles R. Hicks, instructor, and a concurrent Advanced Short Course in Quality Control, Irving W. Burr, instructor, at Purdue University, contact Mr. Hicks or Mr. Burr, Purdue University, Lafayette, Ind.

. . . 5-11—Reliability Training Conference in Chicago, Ill., sponsored by the ASQC Electronics Division and the PGRQC of IRE, instructors—Thomas A. Budne and Harmon S. Bayer, contact Art Roddey, registration chairman, Institute for Defense Analysis, The Pentagon, Washington 25, D. C.

. . . 13-24—Two University of Michigan Engineering Summer Conferences: Models and Simulation in Operations Research, and Foundations and Tools for Operations Research and the Management Sciences, contact R. E. Carroll, Engineering Summer Conferences, University of Michigan, College of Engineering, Ann Arbor, Mich., telephone NOrmandy 3-1511, Ext. 2079.

. . . 13-30—Two sessions of the 17th annual Statistical QC Program for the Chemical Industries, Rochester Institute of Technology, Rochester, N.Y.; 1st session—June 13-20, 2nd session—June 23-30; Applications Seminar—June 21-22, contact Harold M. Kentner, Extended Services Division, RIT, Rochester 8, N. Y.

. . . 14-17—Annual Cornell University Industrial Engineering Seminars, sponsored by the Department of Industrial and Engineering Administration, Sibley School of Mechanical Engineering, Cornell University, Ithaca, N. Y., participants enroll in industrial management, engineering administration, operations management of the smaller company, work measurement, systems simulation using digital computers, statistical decision-making: theory and applications, or statistical reliability analysis: theory and applications, and also attend general sessions, contact J. W. Gavett, seminar coordinator, Department of Industrial and Engineering Administration, Upson Hall, Cornell University, Ithaca, N.Y.

AUGUST

. . . 1-19—1960 Statistical Methods in Industry Course, University of California, Los Angeles campus, five major courses are QC by statistical methods; industrial statistical methods; design and analysis of industrial experiments, industrial reliability, and basic measurements and standards. Participants will have a choice of seven seminar or special laboratory groups and a general lecture series. Instructors include I. W. Burr, Charles Hicks, L. A. Knowler and Robert C. McMaster, contact Edward P. Coleman, Department of Engineering, University of California, Los Angeles 24, Calif.

. . . 15-25—Thirteenth Annual Intensive Course in Quality Control by Statistical Methods, a first course for executives and supervisory personnel, practical and mathematically nontechnical, instructors will be Fred Beeler, Western Michigan University; C. C. Craig, University of Michigan; E. G. Olds, Carnegie Institute of Technology, and Mason E. Wescott, Rutgers University; contact C. C. Craig, course director, 106 Rackham Bldg., Ann Arbor, Mich.

SEPTEMBER

. . . 1-3—European Organization for Quality Control Conference, "Controlling Product Quality—Its Value to Industry," Church House, London, contact British Productivity Council (EOQC 1960 Conference), 21, Tothill St., London, S. W. 1., England.

. . . 11-17—Reliability Training Conference in the Dallas-Fort Worth area, sponsored by the ASQC Electronics Division and the PGRQC of IRE, contact Art Roddey, registration chairman, Institute for Defense Analysis, The Pentagon, Washington 25, D. C.

. . . 26-30—Instrument Society of America Fall Instrument-Automation Conference and Exhibit and 15th Annual Meeting, New York Coliseum, New York, N. Y., contact Director of Technical and Educational Services, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

OCTOBER

. . . 4-7—Tenth Annual Instrument Symposium and Research Equipment Exhibit, National Institutes of Health, Bethesda, Md., sponsored by the Washington sections of the American Association of Clinical Chemists, American Chemical Society, Instrument Society of America, Society of American Bacteriologists, Society for Experimental Biology and Medicine; primary topics include fluorescence, infra-red, activation analysis, ultra-centrifuge, microscopy and electrodes. Contact Herman C. Ellinghausen, Agricultural Research Center, U. S. Department of Agriculture, Beltsville, Md.

. . . 10-15—Reliability Training Conference in Kansas City, sponsored by the ASQC Electronics Division and the PGRQC of IRE, contact Art Roddey, registration chairman, Institute for Defense Analysis, The Pentagon, Washington 25, D. C.

ASQC Annual Convention Future Dates

May 24-26,	1960	San Francisco
June 5-7,	1961	Philadelphia
May 23-25,	1962	Cincinnati
May 20-22,	1963	Chicago
May 4-6,	1964	Buffalo

Mid-Pacific Conference

May 30, 31, June 1, 1960 Honolulu

Chicago Reliability Training Conference

A Reliability Training Conference sponsored by the ASQC Electronics Division and the PGRQC of IRE will be held June 5-11, at the Sheraton Towers Hotel, 505 N. Michigan Ave., Chicago, Ill.

The courses will begin Monday, June 6. Enrollment will be restricted to 35 registrants.

Classes will meet for a total of 50 hours. Approximately 36 of these hours will be devoted to formal lectures. The remaining time will be spent in discussion and tutorial sessions. The discussion will cover selected topics of special interest to the enrollees. The tutorial sessions will be conducted for those who feel a need for further study of the material covered in the lectures.

Guest speakers in the following areas of interest will talk at special evening lectures: Monday—the military looks at reliability; Tuesday—reliability design improvement; Wednesday—case history discussion; Thursday—communication system degradation, and Friday—testing philosophy relating to reliability.

Instructors will be Harmon S. Bayer, Lawrence R. Brown, David T. Armstrong, and Thomas A. Budne.

The program will include design procedures for improving reliability, predicting reliability at different stages of progress, defining reliability in specifications, integration of reliability testing with other testing, reliability during production, vendor and subcontractor reliability, developing an effective failure reporting and corrective action system, maintaining reliability in the field, effective use of statistical and mathematical theory, reliability program management for effective implementation, and contractual aspects of reliability.

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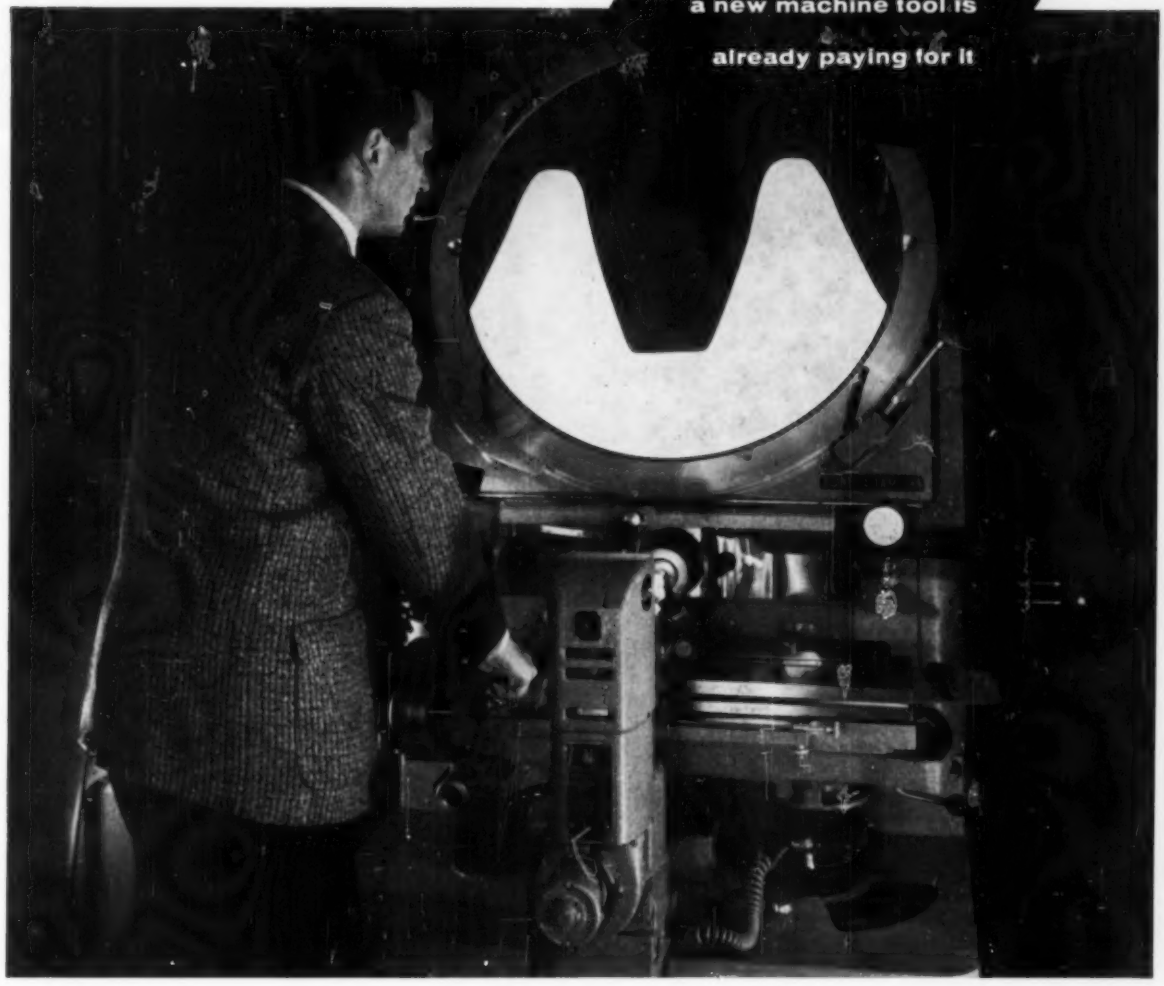

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Jones & Lamson now offers the J & L Mercury Arc Lamp, an entirely new light source unit that gives *more than 5 times the intensity of the best filament light source available today.*

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For detailed information and specifications, or a demonstration, contact your local J & L representative or write direct to Jones & Lamson Machine Company, 510 Clinton Street, Springfield, Vermont.

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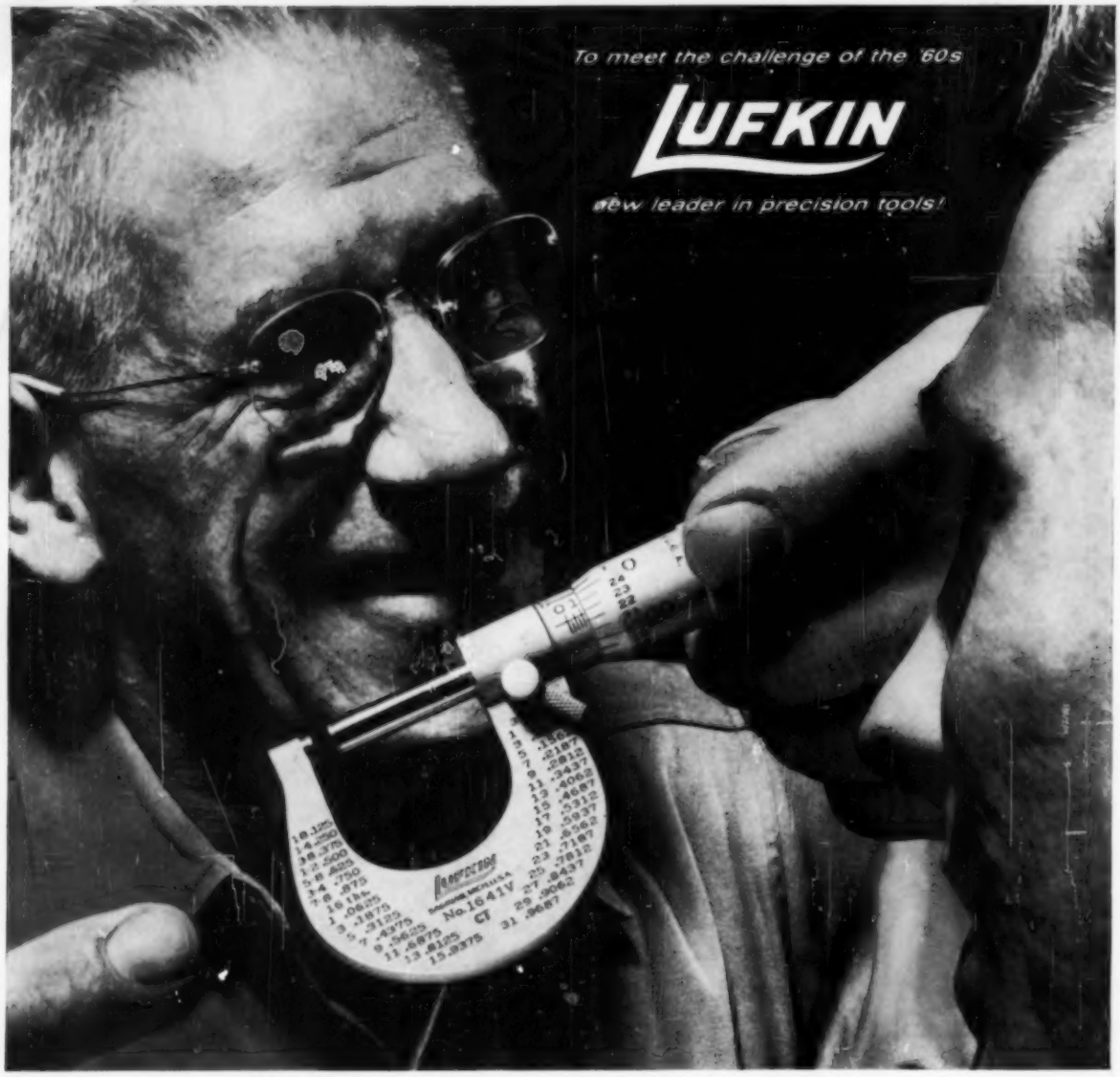

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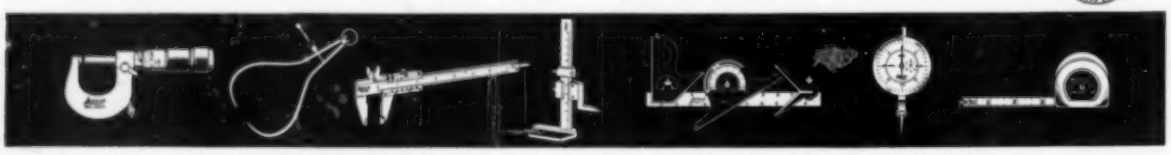
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